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# GEOLOGICAL INVESTIGATIONS OF CHROMITE IN CALIFORNIA

## Bulletin 134

## PART I—KLAMATH MOUNTAINS

## CHAPTER 1

## CHROMITE DEPOSITS OF DEL NORTE COUNTY, CALIFORNIA

By Francis G. Wells, Fred W. Cater, Jr., and Garn A. Rynearson
Geological Survey, U. S. Department of the Interior

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# CHROMITE DEPOSITS OF DEL NORTE COUNTY, CALIFORNIA[**]

By Francis G. Wells,[*] Fred W. Cater, Jr.,[*] and Garn A. Rynearson[*]
United States Department of the Interior, Geological Survey

## OUTLINE OF REPORT

Page
ABSTRACT 3
INTRODUCTION 3
  Geography 3
  Field work and acknowledgments 5
OUTLINE OF GEOLOGY 5
GENERAL FEATURES OF THE PERIDOTITES 7
  Distribution and relations 7
  Lithology 8
  Occurrence of dunite 8
  Landslides 9
LOCAL FEATURES OF THE PERIDOTITES 9
  Middle belt 9
    Main body 9
    Lower Coon Mountain and Summit Valley areas 10
  Southwestern belt 10
  Eastern belt 11
GENERAL FEATURES OF THE CHROMITE ORE 12
  Disseminated ore 12
  Massive ore 13
    Character of ore bodies 13
    Relation to shear zones 13
    Chromium minerals other than chromite 14
  Chemical characteristics of chromite 15
  Assays of ore from Del Norte County 15
PRODUCTION 16
PROPERTIES IN MIDDLE PERIDOTITE BELT 21
  Wimer road area 21
    Copper Creek chromite mine (2) 21
    Mountain View (High Divide) mine (3) 28
    One-Eyed Jack Nos. 1, 2, and 3 (Zoar) (4) 31
    Gooch claim (5) 32
  Hole in the Ground area 32
  High Plateau area 32
    High Plateau mine (13) 33
      History and production 33
      Geology 34
      Mine workings 35
      Reserves 35
      Bench deposits 37
    Bonanza (12) 37
    Judy mine (11) 37
    Bluebird prospect (10) 38
    Skyline mine (9) 39
  Upper Diamond Creek area 39
    Richey property (14) 41
    Logan claim (16) 41
  Patricks Creek area 41
    Toujours Gai claim (17) 43
    Tangerine claim (15) 43
    High Dome claim (19) 43
    Chrome Hill No. 1 claim (18) 45
  Gasquet area 45
    Niggerhead claim (25) 45
    Blackjack chromite claim (24) 46
    Angela chromite mine (23) 46

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[*] Geologist, United States Geological Survey.

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Page

PROPERTIES IN MIDDLE PERIDOTITE BELT—Continued

French Hill area 46
  General features 46
  Margy and Fairview claims (26 and 27) 47
  French Hill chromite mine (28) 47
    Location, history, and production 47
    Geology 47
    General features of the ore deposits 48
    East ore zone 49
    West ore zone 50
    Other deposits 51
    Reserves 52
  Star and Rough and Ready claims (29) 52
Gordon Mountain—Fox Ridge area 52
  General features 52
  Zinc Saddle claim (30) 53
  Coon Mountain group (31) 53
  Coon Creek No. 1 claim (32) 55
  Cooncan claim (33) 55
  Sunset (Darnell) claim (35) 57
  Apex (Goose Egg) claim (34) 57
  Big Dipper (Camp Seven, Rowan) claim (37) 58
  Patterson No. 1 claim (38) 59
  Camp Eight (St. Patrick) claim (39) 59
  Sunrise claim (40) 60
  Gilmore claim (41) 61
  Grumpy claim (42) 61
  Lone Grave Nos. 1 and 2 claims (43 and 44) 61
  Stevens No. 2 claim (45) 62
  Muzzle Loader (Stevens No. 1) mine (46) 63
PROPERTIES IN SOUTHWESTERN PERIDOTITE BELT 65
South Fork area 65
  Fourth of July claim (48) 65
  Hawkins (Billy Boy, Divide) claim (47) 65
  Contact claim (49) 66
Little Rattlesnake Mountain area 66
  General features 66
  Carla claim (50) 67
  Rattlesnake Mountain claim (51) 67
  Section Sixteen claim (53) 67
  Deleray and Rodgers claim (55) 68
  Cuneo (Inman No. 1) mine (52) 68
  Soldier's Well (McClendon) claim (54) 69
  Pigeon Roost Spring claim (60) 69
  Inman No. 2 claim (61) 69
  Crescent claim (62) 69
  Big Five mine (63) 69
  Old Doe mine (64) 70
  Big Buck claim (65) 70
  Midnight (66) and Goose Creek (67) claims 70
  Claim southeast of Mud Spring (68) 71
Red Mountain area 71
  General features 71
  Red Mountain Chrome No. 1 (71), No. 2 (70), and No. 3 (69) claims 71
PROPERTIES IN EASTERN PERIDOTITE BELT 72
Bear Camp Ridge—Doe Flat area 72
  White Feather claim (22) 73
  Ebon claim (20) 73
Dunn Creek area 73
  Alyce and Blue Jay claims (21, 21a) 73
BEACH SAND DEPOSITS 74
  General statement 74
  Crescent City beach deposits 75

## ABSTRACT

Del Norte County, the second largest source of chromite among the counties of California, is in the sparsely settled mountains of northern California. These mountains consist of folded sedimentary and volcanic rocks, which while being folded were intruded first by peridotite and then by several other kinds of igneous rock. The ultramafic rocks crop out over hundreds of square miles, and are known to underlie more than a quarter of the county. The chromite deposits occur in the peridotites and in serpentine derived from them.

The chromite deposits are of two types—pod deposits and disseminated deposits. Pod deposits, which include almost all of those in Del Norte County, consist of massive chromite that can be mined, sorted, and shipped as lump ore. Seventy-one chromite deposits have been opened up in the county, and ore has been shipped from 50 deposits, containing from 5 to 20,000 long tons. Two deposits are known to have yielded over 10,000 long tons, one other more than 5,000, and another more than 3,000. Ten are known to have yielded between 100 and 1000 long tons, five between 50 and 100, and five less than 50.

The ore of Del Norte County is mostly of metallurgical grade. In all of it the Cr/Fe ratio exceeds 2.50, and in much of it the ratio is 3.0 or better. The $Cr_2O_3$ content is rarely below 45 percent, and in many thousand tons of ore it has been at least 50 percent.

The known shipments from Del Norte County, up to December 31, 1944, total 59,420 long tons. The chromite pods vary so widely in size and shape that the only ore whose tonnage can be measured is that which has been completely exposed, and of such ore the county contains very little. Of indicated ore, there is about 10,000 long tons. Of inferred ore—ore that might be developed or discovered with adequate incentive—the writers estimate that the county contains about 50,000 long tons.

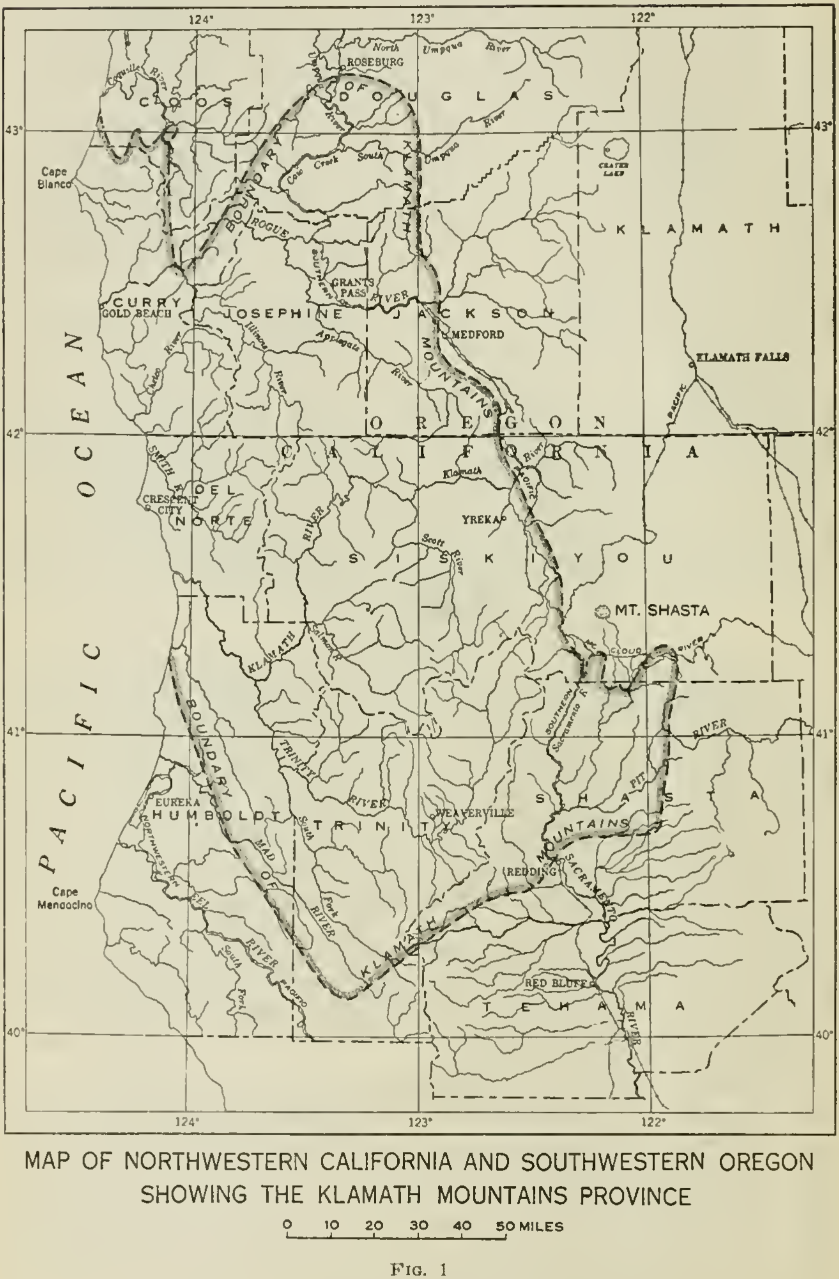
Chromite is so resistant to weathering that much of it is carried by streams to the sea, and concentrated with other heavy resistant minerals in ocean beaches. Near Crescent City there are beach deposits containing 5 to 15 percent $Cr_2O_3$, but none of them has been accurately measured or thoroughly sampled.

## INTRODUCTION

### Geography

Del Norte County, which up to December 31, 1944, was second only to San Luis Obispo County as a producer of chromite ore and the largest producer of lump ore among the counties of California, comprises an area of 1003 square miles in the northwest corner of the state. It lies west of Siskiyou County and north of Humboldt County. From the Oregon line to Smith River the county is bordered by a coastal plain about three-quarters of a mile wide. At the mouth of Smith River the plain broadens, attaining a width of about 4 miles; from there its eastern margin continues southward 14 miles, until it meets the eastward-curving shoreline a short distance south of Crescent City. The area of the coastal plain is 58 square miles. The remainder of the coast is bold and rocky. Except for the coastal plain, the county lies within the Klamath Mountains and is very rugged. The eastern boundary of the county is formed by the crest of the Siskiyou Mountains, the crowning peaks of which are about 6,000 feet high.

Naturally such a region is sparsely populated. According to the 1940 census the total population was 4,745, largely settled on the coastal plain. Crescent City, the county seat and largest community, had in 1940 a population of 1,363. No railroad enters Del Norte County, but there is an airfield near Crescent City. U. S. Highway 101 follows the coast, and U. S. Highway 199 connects Crescent City with Grants Pass, which lies 87 miles to the northeast and is the commercial center and railroad shipping point for much of the region. During the last decade the Civilian Conservation Corps and the Forest Service have built many miles of forest road, but large parts of the county are still remote from any road.



MAP OF NORTHWESTERN CALIFORNIA AND SOUTHWESTERN OREGON SHOWING THE KLAMATH MOUNTAINS PROVINCE

FIG. 1

The coastal plain and those parts of the valleys of Smith and Klamath Rivers that are less than 500 feet above sea level have a mild climate, with a long rainy season and heavy rainfall. The average annual rainfall at Crescent City is 74 inches.[1] The mountains are covered with snow from November until April.

The abundant rainfall favors a lush vegetation except on the peridotites, which are so thoroughly fractured and therefore so rapidly and deeply drained that they support only a few scattered yellow pine and a stunted growth of manzanita. Primeval groves of magnificent redwood trees (*Sequoia sempervirens*) still stand on the coastal plain and on the mountains below an altitude of 2200 feet. The virgin forests contain an abundance of spruce, fir, pine, and cedar. Where these have been burned or cut, myrtle, manzanita, salal, rhododendron, chinquapin, and other shrubs or dwarf trees form almost impenetrable thickets.

### Field Work and Acknowledgments

The chromite deposits of the Pacific Coast states were studied by the Geological Survey, U. S. Department of the Interior, from July 1938 to October 1944, the work being part of a nation-wide investigation of strategic minerals. Except for two reconnaissance trips to the major deposits made by Wells in 1939 and 1940, the Geological Survey did no work in Del Norte County until the autumn of 1941. Since then almost every reported deposit has been examined, and all deposits that have yielded as much as 1,000 long tons of shipping ore have been mapped in detail. F. W. Cater, Jr., D. H. Dow, D. E. Flint, A. B. Griggs, F. W. Gros, G. A. Rynearson, S. D. Wells, Jr., and W. P. Williams assisted in the field work, under the immediate supervision of Francis G. Wells.

The topographic base of plate 1 is taken from topographic maps prepared for the Corps of Engineers, U. S. Army, by the U. S. Department of Agriculture, Forest Service, and from topographic maps of the Geological Survey.

This report has been written for the most part by the senior author, but it contains much unpublished material by the junior authors, whose descriptions of the Tyson-French Hill, Mountain View (High Divide), and Copper Creek mines have been used with but little change.

Many people in Del Norte County earned the gratitude of the Geological Survey party during the prosecution of this work, by courtesy and kindness as well as aid and cooperation. The mine operators, especially Messrs. B. C. Mickle, John Noce, Eugene Brown, Charles Bennett, and J. K. Remsen, and H. C. Obye and C. D. Cameron, Supervisor and Engineer respectively of the Siskiyou National Forest, never missed an opportunity of being helpful. The writers are also indebted to several colleagues in the Survey, especially to Frank C. Calkins, for aid in the preparation of this report.

## OUTLINE OF GEOLOGY

Del Norte County shares the complicated stratigraphy and structure that prevails throughout the Klamath Mountains province. Its geology has been reconnoitered and mapped, but some of even its larger geologic problems must remain unsolved until more detailed work has been done.

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[1] U. S. Department of Agriculture, Climatological data.

The western part of the county, for a distance of as much as 10 miles from the ocean, is mostly underlain by sandstone and shale with intercalated volcanic rocks. The sandstone is dark gray in color, and is made up of thoroughly hardened arkosic material. This rock occurs in thick layers that show little bedding. Shale, which is much less abundant, forms thin layers interbedded with the sandstone. Lenses of chert are common in the lower part of the formation. Intercalated with the sediments are large masses of green, generally fine-grained igneous rocks, consisting of volcanic flows and agglomerates, and both the sedimentary and the volcanic rocks are cut by dikes and larger intrusive bodies of dioritic composition. These rocks have not yielded any fossils in Del Norte County, but they have been traced northward to Rogue River, where they are overlain by less indurated sandstone, shale, and conglomerate containing characteristic Knoxville fossils. As they underlie the Knoxville formation and are lithologically similar to the Franciscan rocks in the Coast Ranges, they are correlated with the Franciscan, which is probably of Jurassic age.

Metavolcanic and metasedimentary rocks of Triassic age, studied in the Kerby quadrangle, Oregon,[2] extend south-southwestward through the eastern part of the county, with steep easterly dips. Downfaulted against these Triassic rocks on the west is the Galice formation, of Jurassic age, which has been traced into Del Norte County from Galice, Oregon, and is correlated with the Mariposa formation[3] of the Sierra Nevada province. In its type locality the Galice formation consists mainly of black indurated shale, partly metamorphosed into slate, but it includes arkosic sandstone with intercalated volcanic material.

The Mesozoic sedimentary and volcanic rocks have been invaded by the intrusive rocks that contain all of the chromite deposits which form the main subject of this report. These intrusives belong to the class that petrographers call ultramafic rocks, but for the most part they fall within the subdivision of their class known by the somewhat more familiar term peridotite. A term that is even more widely applied to them is serpentine, which properly means a peridotite that has been affected, in some degree, by a kind of alteration to which most peridotite has been subjected not only in Del Norte County but almost everywhere. These rocks, unlike the others mentioned in this outline, will be described at some length below, under the head of peridotite.

Small bodies of diorite and quartz diorite have been intruded into the pre-Tertiary sedimentary rocks and the peridotites, especially in the eastern part of the county.

Most of the marine terrace in the vicinity of Crescent City is underlain by Tertiary marine deposits, isolated remnants of which are found also on mountain ridges to the east, at altitudes of 1700 to 2200 feet above sea level. The deposits on the ridges were named by Diller[4] the Wymer formation, and similar beds containing many of the same fossils are exposed in the Crescent City terrace. These beds are of Miocene age.

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[2] Wells, F. G. and Hotz, P. E., Mesozoic volcanic series in southwest Oregon: (abstract) Geol. Soc. America Bull., vol. 52, pt. 2, pp. 1937-1938, 1941.

[3] Diller, J. S. and Kay, G. F., U. S. Geol. Survey Geol. Atlas, Riddle folio (no. 218), p. 3, 1924.

[4] Diller, J. S., Topographic development of the Klamath Mountains: U. S. Geol. Survey, Bull. 196, pp. 31-35, 1902.

Resting on them disconformably in the terrace are Pliocene sandstones and shales, which are overlain in turn by Pleistocene deposits. It is believed that the concentrations of heavy chromiferous sands in the recent beaches are derived from the Tertiary formations and that commercially noteworthy deposits of heavy sand are limited to areas where Tertiary sediments are being or have been re-worked.

As the peridotites contain all the chromite deposits, they alone will be described further.

## GENERAL FEATURES OF THE PERIDOTITES

Chromite, the only ore of chromium, is an almost constant accessory of peridotites and is found only in such rocks or their alteration products. In the Pacific Coast states, noteworthy concentrations of chromite are apparently restricted to a variety of ultramafic rock called dunite. Prospecting for chromite in place can therefore be confined to areas underlain by ultramafic rocks, and intensive search can be further limited to bodies of dunite where that rock can be distinguished; in many places, however, the peridotites are so greatly sheared and serpentinized that dunite cannot readily be distinguished from the more common variety saxonite.

### Distribution and Relations

The peridotites of Del Norte County may be regarded as forming three belts. By far the most extensive is the middle belt. This consists mainly of the southern part of the great Josephine mass, which extends, from the state line, about 50 miles northward into Oregon and 18 miles southward into Del Norte County. Two relatively small outliers are also included in this belt, one to the southwest, at Lower Coon Mountain, and one to the south, at Summit Valley. Second in extent is what will be called the southwestern belt. This is joined to the middle belt by a narrow strip running north from Smith River, from which it extends south-southeastward, beyond the southern boundary of the county, to Klamath River. It includes the crests of Rattlesnake and Red Mountains. An irregular group of areas lying east and southeast of the middle belt, partly within Del Norte County but extending into Siskiyou County and Oregon, will be called the eastern belt. The largest area in this belt is the one that includes Ship Mountain, on the west side of which it almost merges with the middle belt.

The peridotites were intruded into sandstone, shale, and metavolcanic rocks of Mesozoic age, probably after those rocks were slightly folded. Where thick and extensive layers of metavolcanic rocks occurred, they tended to act as struts in the yielding sediments and thus formed pockets of low pressure into which the peridotite magma tended to flow. The intrusive bodies are tabular in shape, and most of them are rudely conformable with the enclosing rocks. They were somewhat folded during the continued deformation, perhaps while they were still plastic; at any rate they flowed slightly, so that they thickened somewhat on the crests and thinned on the limbs of the folds. The metavolcanic rocks yielded largely by faulting. With continued compression, steep reverse faults striking parallel to the folds further deformed the ultramafic bodies, and movement has recurred on these faults from time to time.

The ultramafic rocks in Del Norte County have been roughly mapped by the writers by reconnaissance methods (see plate 1). All the roads and most of the trails were traversed. As the peridotite generally bears a sparser vegetation than most of the other rocks, and as its outcrops have a characteristic reddish color, it could be mapped rather rapidly with about as much accuracy as the scale of the general geologic map (pl. 1) would permit. Where there are chromite deposits, or where roads and trails are numerous, it has been possible to work out the contact relation of the peridotite in detail and to determine the character and structure of the enveloping rocks. A geological reconnaissance map of the northern half of Del Norte County has been made by Maxson,[5] and the distribution of peridotite east of longitude 124° 45′ shown in plate 1 has been taken from this map with modifications by the writers.

### Lithology

Ultramafic rocks are igneous rocks containing little or no feldspar and characterized by one or more of the common magnesium-iron silicate minerals olivine, pyroxene, and amphibole. Those in Del Norte County include at least two small areas that may consist largely of pyroxenite—a rock consisting mainly of pyroxene—but in the main they consist of peridotite, which is the name applied to rocks consisting chiefly of olivine.

Peridotite may contain more or less pyroxene, which is chiefly enstatite but in many places includes augite and, much more rarely, chrome diopside; and it contains magnetite and chromite as accessory minerals. The relative abundance of these minerals may vary greatly in different parts of a single rock mass. In this report a rock that contains 95 percent or more of olivine is termed dunite; one that contains less olivine, the remainder being chiefly enstatite, is called saxonite. Both dunite and saxonite are common in Del Norte County, but saxonite is by far the more abundant. Olivine and enstatite both alter to serpentine. Enstatite alters to bastite, a material having the composition of serpentine, a bronzy color and a satiny luster. Both enstatite and bastite weather less rapidly than either fresh or serpentinized olivine, so that weathered saxonite has a rough surface, studded with projecting crystal grains of enstatite or bastite left exposed by the wasting of the fresh or serpentinized olivine. Dunite, on the other hand, has a smooth weathered surface. Weathering of either kind of peridotite liberates oxides of iron, which color the rock surface and soil a strong yellowish-red, but beneath this coating the unweathered rock has the dark green to nearly black color and waxy luster of serpentinized olivine, or the water-green color and vitreous to greasy luster of fresh olivine. The soil on peridotites is generally thin, and vegetation relatively sparse.

### Occurrence of Dunite

The ratio of dunite to saxonite in different peridotite masses varies widely. In some masses, the Seiad Creek-Red Butte mass for example, the rock is more than half dunite; in others only a few percent of the rock is dunite. The dunite bodies may be of any size and of any shape, and may occur anywhere within a mass of peridotite. The larger they are the more they tend to be of simple form. Small bodies, a few yards in diameter, are likely to be very irregular, with tongues extending into the adjacent saxonite. Chromite invariably occurs in dunite, but a pod of chromite may be separated from the surrounding saxonite only by a thin rind of dunite. Where that is the case the dunite, especially if sheared, gives little help in locating the chromite deposits.

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[5] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwesternmost California: California Jour. Mines and Geology, vol. 29, pl. IV, 1933.

### Landslides

Erosion has been very rapid in Del Norte County during the recent geologic past, and the streams have cut deep, narrow canyons. Where the country rock has not been structurally strong, landslides on a considerable scale have taken place. That is the case in the peridotites, and there are many large landslides along the master streams that cut through those rocks. Landslides can be recognized by the presence of irregular benches along the sides of the canyons; these may be at any altitude, and some are higher than any of the stream terraces. The landslide benches commonly slope toward the mountain, whereas benches cut by erosion always slope toward the stream. A depression is likely to be formed at the back of a landslide bench, and a deep depression may contain a pond. At many places in Del Norte County the fracture along which the rock broke away from the mountain can be clearly seen. The surface of a recent landslide is likely to be rough and to consist of jumbled rock, and the rock beneath the surface may be thoroughly broken and contain open spaces filled with mud and water. Such broken, waterlogged rock makes heavy ground, difficult and dangerous to mine. As landslides obviously change the surface distribution of the rocks and may conceal their original relations, they are mapped on the large-scale maps.

## LOCAL FEATURES OF THE PERIDOTITES

### Middle Belt

The middle belt has been arbitrarily defined as including the southern end of the great Josephine intrusive body, which lies mainly in Oregon, and two relatively small outliers to the south, one in Lower Coon Mountain and the other at Summit Valley. The main body is connected on the west by a very narrow strip with what will be described separately as the southwestern belt.

#### Main Body

The Josephine body is 10 miles wide at the state line, from which it extends about 20 miles south to the South Fork of Smith River. Near the latitude of the Middle Fork of Smith River its width contracts rather abruptly, and two tongues of it cross that stream; the larger, at the east, includes Gordon Mountain and part of Fox Ridge; the smaller, at the west, extends across French Hill.

On the west side this body of peridotite is bounded at the north by Franciscan rocks and farther south by the Galice formation. On the east it is bounded mainly by the Galice, but partly by later intrusive rocks. The Galice formation dips eastward on the east side of the peridotite; on the southern and southwestern contacts it dips in various directions.

The structure of the body is highly complex and is far from being completely worked out, the evidence being obscure in some critical areas. At the state line the peridotite appears to be limited on both sides by faults dipping to the east. About 2 miles south of High Divide it is bordered on the west by alternating slices of peridotite and metavolcanic rocks, probably as a result of faulting rather than intrusion. The peridotite appears to be involved in two or more anticlines; the French Hill mine is on the crest of one, and the Baldface anticline of southern Oregon extends southward under and beyond High Plateau, near the center of the main area in Del Norte County. If, as appears possible, the peridotite body is roughly accordant with the sedimentary rocks, it must be at least 3000 feet thick, and if it is not accordant it may be very much thicker. The rock in this body is dominantly saxonite, serpentinized in widely varying degrees. On some upland surfaces, such as High Plateau, and in some canyons, it is very little serpentinized, while along some faults and shear zones it is altered to slickentite.

This body of peridotite contains many clusters of chromite deposits, distributed without much regularity but rather more numerous near the margins than in the center. Three clusters have yielded as much as 10,000 long tons of high-grade lump ore apiece, and two have yielded more than 10,000 long tons. These five highly productive areas are the Wimer Road area, near the western contact, the High Plateau area, in the central part of the mass, the French Hill area, at the crest of the narrow tongue, the Patricks Creek area, near the eastern contact, and the Gordon Mountain-Fox Ridge area, in which the pods are scattered but generally near the western contact. Areas with a small production include the one at the head of Myrtle and Hardscrabble Creeks and the Hole in the Ground area, both near the western contact, and the Upper Diamond Creek and Gasquet areas, both near the eastern contact.

### Lower Coon Mountain and Summit Valley Areas

Sitting across Lower Coon Mountain like a saddle is a mass of pyroxenite 1½ miles wide and 2½ miles long. On the flat top of the mountain the pyroxenite is largely covered with sand and clay of Tertiary age. The pyroxenite is a coarse-grained rock, apparently not serpentinized, consisting of pyroxene crystals about ¼-inch to 1 inch long. This mass is surrounded by slate, shale, sandstone, and metavolcanic rocks of the Galice (?) formation, and is believed to occupy a syncline. As chromite is rarely found in pyroxenite except in scattered grains, this area can be considered barren.

In T. 14 N., R. 3 E. there is a long irregular body of peridotite, about 8 square miles in area (see pl. 1). Its northern end lies just south of the South Fork of Smith River and its southern end a little south of Summit Valley. It has pyroxenite borders, and detailed study may show that it is mostly pyroxenite, with some saxonite but little or no dunite. It appears to occupy a syncline, and thus to be allied with the Lower Coon Mountain mass in structure as well as in composition. No chromite occurrences have been reported from this area, and it seems unlikely to contain any accumulation of chromite that would yield so much as 100 tons of shipping ore.

### Southwestern Belt

The southwestern peridotite belt is connected by a narrow strip north of Smith River with the great Josephine intrusive body. From Smith River it extends in a general south-southeasterly direction beyond the southern boundary of the county. It is narrow in comparison with its great length, but reaches a maximum width of 3 miles in Little Rattlesnake Mountain.

This belt is bounded on the west by Franciscan (?) sandstone and shales. For 3 miles south of Smith River it cuts across the strike of these beds, and in the bed of Smith River the contact, which dips 45° or more eastward, is faulted and the peridotite alternates with slices of metavolcanic rocks. Maxson indicates a fault extending along the full length of this western contact,[6] but not enough field work was done during the present investigation to prove whether or not he was justified in doing so.

Along its eastern contact the peridotite is flanked by metavolcanic rocks from Smith River south to the fault at the mouth of Coon Creek, and farther south by the Galice formation. The actual contact was not seen at any place along this stretch, but it is believed to be at least in part conformable. It dips steeply eastward and in places may be vertical. In some places south of Coon Creek the peridotite has been intruded by gabbro. From Coon Creek north the peridotite body appears to be a dike-like mass cutting across the strata; between Coon Creek and Rattlesnake Peak it is probably on the crest of the same anticlinal flexure that was seen at the French Hill mine; from there south to Red Mountain it is either on the west limb of the fold or is a dike; and from Red Mountain south it is on the crest of an anticline.

The belt consists mainly of saxonite, which is everywhere partially serpentinized, and, wherever it could be seen close to the contact or to faults, so thoroughly serpentinized and sheared as to form slickentite. The known chromite deposits are nearly all in the eastern part of the body, south of the point where the South Fork of Smith River leaves it.

### Eastern Belt

The largest area in the eastern belt is the one that includes Ship Mountain. The north end of the Ship Mountain peridotite mass is about half a mile north of the Middle Fork of Smith River, and the south end 18 miles or more to the south, a little beyond the South Fork of Smith River. At the Middle Fork the mass is about a quarter of a mile wide. It widens irregularly southward until it attains its greatest width, 2½ miles, in the conspicuous red top of Ship Mountain, south of which it narrows again. The northern and southern ends are irregular in outline, and it is uncertain whether they occupy the steep limbs of folds or are steep cross-cutting bodies, but the broad central part of the mass probably occupies the crest of an anticline. The peridotite is flanked on the west by eastward-dipping sediments of the Galice formation, as it is also along the northern part of its eastern boundary, but along the southern part of that boundary it is intruded by quartz diorites and related rocks.

This area is very rugged and has not been studied in detail, nor has it been prospected, but it is known to contain some concentrations of chromite and it merits intensive prospecting. It can now be reached by way of trails from Big Flat and from the Bear Basin road.

The second largest area in the eastern belt is the Bear Camp Ridge-Doe Flat area, a band of peridotite that extends almost due south from the Oregon border to Doe Flat, a distance of 12 miles. This band is nowhere more than 2 miles wide, and in places its width narrows to a third of a mile. The peridotite is bounded on the west by rocks of the Galice formation, dipping steeply eastward, and on the east mainly by metavolcanic rocks of Triassic age.[7] The western contact shows complex faulting, and the eastern contact is complicated by bodies of diorite, granodiorite, and related rocks intruded into both the peridotite and the metavolcanic rocks. The peridotite is serpentinized and highly sheared along much of its length.

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[6] Maxson, J. H., op. cit., pl. IV.

According to the geologic map made by Maxson, an elongate body of peridotite is exposed in the valley of Dunn Creek, in the northeast corner of Del Norte County (see pl. 1). This mass divides at the forks of the creek, and the western projection extends south along the ridge dominated by Black Butte and Lookout Mountains, which are shown as diorite on Maxson's map. The rocks into which the peridotite has been intruded are believed by the writers to be Triassic in age. In general the pod deposits found in peridotite intruded into the rocks of this age are not large, and only two chromite deposits have been opened up in this area.

## GENERAL FEATURES OF THE CHROMITE ORE

Accumulations of chromite large enough to be mined may be more or less mixed with the host rock, or they may form dense aggregates of crystals. In the former case they are called disseminated ore, and in the latter case massive ore.

### Disseminated Ore

Disseminated ore may consist of chromite grains scattered at random through dunite, and more frequently it consists of narrow schlieren,[8] in which the chromite grains may constitute from 20 to 90 percent of the mass. A schliere is usually surrounded by a relatively thin shell of transitional rock, which grades outward into barren dunite. In many places irregular bodies of dunite, enclosing straight or sinuous wisps, comet-shaped schlieren, lumps, and whorls of chromite, are scattered widely and at random through the peridotite. Masses of disseminated ore occurring in nearly straight ill-defined zones are common in Del Norte County. In some places tabular or cylindrical schlieren are grouped, and they may alternate more or less regularly with dunite, so as to give the rock a banded appearance. Such material may sometimes be hand-cobbed to a shipping grade. When viewed broadly, these bodies appear to lie generally parallel to the major axes of the peridotite mass, but in detail they may be much contorted. If a body of disseminated ore is ellipsoidal, its longest axis may lie parallel to other linear elements in the mass. So far as is now known, bodies of disseminated ore, though always enclosed in dunite, may occur in any part of a mass of peridotite. A mineable body may contain as little as a few hundred pounds or as much as 100,000 tons of ore that is at least 25 percent chromite. Rarely does any one group of closely spaced chromite schlieren contain more than a few thousand tons, but in places a large number of such groups are so bundled together that they could be mined as one large deposit, containing tens of thousands of tons of ore and surrounded by peridotite nearly barren of chromite. More detailed descriptions of such bundles are given in other published reports.[9]

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[7] Wells, F. G., and Hotz, P. E., op. cit., p. 1937.

[8] *Schliere*: An irregular portion of an igneous rock, ordinarily not everywhere sharply bounded, that differs in texture or composition from the rest of the mass but forms an essential part of it.

## Massive Ore

### Character of Ore Bodies

The dense aggregates of massive chromite are frequently called lenses or kidneys by the miner, but their forms are so widely varied and in part so irregular that terms of such definite meaning seem inappropriate. The writers prefer to apply to them the more noncommital term "pod deposits."

The content of such a deposit may be anywhere between a ton and 10,000 tons. Allen[10] classified chromite deposits as (1) small, containing less than 100 long tons; (2) medium, containing 100 to 1,000 long tons; and (3) large, containing more than 1,000 long tons. Of the 235 deposits that he lists, he classes 48 percent as small, 24 percent as medium, and 28 percent as large. But this list includes many disseminated deposits, and the deposits that he described were probably above average in size. For these reasons and others, it seems likely that the percentage of large deposits in Del Norte County will prove to be much smaller than 28. Of the 71 chromite deposits in the county that have thus far been productive, 72 percent are small, 20 percent medium, and only 8 percent large. All these deposits are of the pod type, and it seems a fair guess that of the new finds in Del Norte County, which will probably include some deposits of disseminated ore, about 10 percent will be large and about 25 percent medium. Usually there is no correlation between the size of a chromite deposit and that of the peridotite mass within which it is enclosed, except that the largest ore deposits occur in the largest masses of peridotite.

### Relation to Shear Zones

Pod deposits frequently, but not always, occur in shear zones, which may be as much as several hundred feet wide and many miles long, or as little as 20 feet wide and only a few hundred feet long. Shear zones are characterized by greenish-gray to honey-colored, more or less translucent serpentine forming flakes and lenticular lumps with polished surfaces. The miners call this variety of serpentine "slickentite"—a term so descriptive that it seems worthy of adoption. As slickentite erodes readily, it usually underlies depressions in the surface. Roads that traverse peridotite bodies, are therefore likely to be mainly in skickentite, and many people consequently get the mistaken idea that peridotite, or the serpentine derived from it, is all of this character.

Shear zones tend to seek out zones of weakness. The contact of the peridotite with the older rocks is necessarily a zone of weakness, inasmuch as two different kinds of rock are readily broken apart. When fissures form along the border, the marginal peridotite rapidly becomes serpentinized and consequently weakened still further, so that under continuing stress it becomes thoroughly sheared. Fissures likewise tend to form at the borders of dunite masses enclosed in saxonite.

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[9] Wells, F. G., Page, L. R., and James, H. L., Chromite deposits of the Pillikin area, Eldorado County, California: U. S. Geol. Survey Bull. 922-O, pp. 424-437, 1940.

Rynearson, G. A., and Wells, F. G., Geology of the Grey Eagle and some nearby chromite deposits in Glenn County, California: U. S. Geol. Survey Bull. 945A, pp. 5-22, 1944.

Wells, F. G., Smith, C. T., and Livermore, J. S., Chromite deposits of the Seiad Creek area, Siskiyou County, California: In preparation.

[10] Allen, J. E., Geological investigation of the chromite deposits of California: California Jour. Mines and Geology, vol. 37, pp. 106, 110, 1941.

Whenever two intermingled rocks greatly differing in hardness are intensely sheared, the hard rock tends to break up into blocks, which, though at first angular, become abraded by the ensuing movement into smooth, polished, rounded bodies resembling horses in veins. The rounded masses of chromite in the peridotite shear zones have had such a history. These are sometimes called knockers, and will be called so here. Knockers of chromite may be widely spaced, closely spaced, or overlapping. Which condition exists in any deposit cannot be predicted, as it depends on the shape and size of the original pod or pods and the kind of shearing they have undergone. The attitude of the knockers will depend on the original orientation of the chromite pod and the dragging out or rotation that it has undergone during deformation. In prospecting for knockers of chromite, one should follow the direction of elongation of knockers or strings of knockers already discovered. The angle that this direction makes with the horizontal is called the plunge, and the plunge tends to remain constant throughout the peridotite that occupies the same part of a structure—that, for example, on either flank of a fold, or on its crest.

Knockers are found only in sheared serpentine, but not all shear zones contain chromite. There is no evidence that chromite pods were formed in shear zones after the shearing took place; the pods were there first, and caused a weakness in the peridotite that made it especially liable to shearing. Pods, moreover, are always enclosed in dunite, which is more readily serpentinized than saxonite, and when serpentinized is readily sheared. A shear zone well within a mass of peridotite may therefore be a little more likely to contain massive chromite than a shear zone along the contact. As it cannot be due to the weakening influence of the contact, it is all the more likely to mark the position of a streak of dunite, or a string of dunite bodies, which may have contained pods of chromite.

### Chromium Minerals Other Than Chromite

Chromium-bearing minerals other than chromite that are found with ore are present in very small amount and are of no commercial value, but they are of scientific interest and may throw some light on the origin of the deposits. They include the chromium garnet uvarovite and the chromium chlorite kammererite. Chromium-bearing pyroxene, which is often a brilliant green, was not recognized.

Uvarovite is emerald green, has a vitreous luster, and is harder than quartz. It forms incrustations of tiny perfectly formed dodecahedrons or trapezohedrons on joint surfaces in homogeneous chromite. It is found in small quantities at many of the chromite occurrences in Del Norte County and is abundant at the High Plateau mine.

Kammererite is soft, micaceous, and lavender to pink in color. Small plates of it are common in chromite and the contiguous gangue. Where well developed it forms hexagonal plates or books of plates. The mineral that has been called kammererite at the High Plateau mine may be kotschubeite, another chromium-bearing chlorite.

### Chemical Characteristics of Chromite

Chromite, the only ore mineral of chromium, is a spinel. Most of the spinels are isomorphous mixtures[11] of several end members, and chromite is a mixture in varying proportions of magnesiochromite, ($MgO.Cr_2O_3$), spinel, ($MgO.Al_2O_3$), magnesioferrite, ($MgO.Fe_2O_3$), ferrochromite, ($FeO.Cr_2O_3$), hercynite, ($FeO.Al_2O_3$), and magnetite, ($FeO.Fe_2O_3$). A dozen grains of pure chromite, therefore, may all differ distinctly from one another in composition; each may contain a measurably different percentage of chromium, of iron, of aluminum, and of magnesium from every other. The chromium content of chromite is usually stated in percent of chromic oxide. Some chromite analyzed in the laboratory of the Geological Survey contained more than 61 percent of $Cr_2O_3$.[12] The market value and utility of chromite depends not only on the chromium content but on the iron content as well; the chromium-iron ratio, which is the percentage of chromium divided by the percentage of iron, is one of the factors considered in judging the desirability of a chromite ore. Specifications for metallurgical chromite ore usually call for a $Cr_2O_3$ content of 45 percent or better and a chromium-iron ratio of not less than 3. In ore to be used as a refractory, alumina content, also, is important; and ore should contain at least 60 percent of chromic oxide and aluminum oxide ($Al_2O_3$) together.

Silica is an undesirable constituent; specifications for metallurgical ore require that $SiO_2$ content shall not be over 10 percent. All the massive chromite, however homogeneous, that has been analyzed by the Geological Survey contains a few to 10 or 15 percent of silicate minerals, which coat the chromite grains or fill spaces between them.

To determine the value of disseminated ore it is necessary to have an analysis of chromite carefully concentrated from a fairly large sample. Analyses of lumps of coarse-grained material picked from a body of disseminated ore do not necessarily give the composition of the concentrate; it has often been found that picked ore of this character carries a higher percentage of chromium than a concentrate made from run-of-mine disseminated ore in the same ore body.

### Assays of Ore From Del Norte County

Only one complete and seven partial analyses of carefully cleaned chromite from ores in Del Norte County are available, and the samples analyzed are not especially representative, each having been selected for analysis in response to some special need that arose during the critical war period (see tables 1 and 2).

One of the samples analyzed—the ore from the Old Doe mine (F.G.W.-71-43, table 2)—contained 59.70 percent $Cr_2O_3$. Pure chromite from the High Plateau mine would probably run at least as high, for truck-load lots from that mine have assayed as high as 54.98 percent $Cr_2O_3$. It might run even higher, for some truck-load lots had a chromium-iron ratio of 3.74, as compared with 3.57 for the sample from the Old Doe mine. Both ores are homogeneous. The lowest chromic-oxide content and the highest iron content, and therefore the lowest chromium-iron ratio, thus far determined by assay was found in purified concentrates of disseminated ore from the Coon Creek No. 1 claim. This mate-

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[11] Stevens, R. E., Composition of some chromites of the Western Hemisphere: Am. Mineralogist, vol. 29, p. 24, 1944.

[12] Stevens, R. E., idem., analysis 45, p. 14, 1944.

*Table 1—Complete analysis of composite sample from ore bin at the French Hill mine*

(F.G.W.-11-42)

Analyst, M. K. Carron

| | Percent | | Percent |
|---|---|---|---|
| $Cr_2O_3$ | 47.95 | $TiO_2$ | .38 |
| $Al_2O_3$ | 14.75 | $SiO_2$ | 2.27 |
| $Fe_2O_3$* | 4.68 | $H_2O-$ | .12 |
| FeO* | 14.41 | $H_2O+$ | .58 |
| MgO | 13.64 | $P_2O_5$— | .04 |
| MnO | .22 | S | None |
| CaO | .54 | | 99.62 |

| | | | |
|---|---|---|---|
| Cr | 32.81 | Impurity | Serpentine |
| Fe | 14.48 | $Cr_2O_3$ in ore shipped | 43.68 |
| Cr/Fe ratio | 2.27 | Percent chromite in ore | 91.1 |

* Calculated from total iron to give RO: $R_2O_3$ 1 to 1.

rial assayed 46.15 percent $Cr_2O_3$ and 14.31 percent Fe, giving a Cr/Fe ratio of 2.21. Disseminated ore may have a very high chromic-oxide content, as some of that from Seiad Creek is known to have,[13] but it also has a high iron content and therefore a medium to low chromium-iron ratio.[14]

Most of the chromite ore mined hitherto in Del Norte County contains more than 40 percent $Cr_2O_3$, and with careful mining the ore shipped should contain an appreciably higher percentage. Much of the chromite contains more than 45 percent $Cr_2O_3$, and with careful mining should furnish ore of that grade or better (see table 3). Probably none of the chromite of Del Norte County has a chrome-iron ratio below 2.20; in most of it the ratio is higher than 2.50, and in much of it higher than 3. Most of the shipping ore would presumably have a Cr/Fe ratio of at least 2.50.

As already remarked, the composition of the ore in a single pod may be far from uniform, and the composition of chromite ore in pods that are bunched together may differ from pod to pod, as at the French Hill mine. Some of this variation is due, of course, to differences in the amount of interstitial gangue. The analytical data do not show whether or not it is partly due to variations in the composition of the chromite, but analyses of samples across larger ore bodies in Cuba indicate that variation of the pure chromite due to that cause is not economically significant.

## PRODUCTION

Seventy-one deposits of chromite have been discovered and worked in Del Norte County, and up to December 31, 1944 had yielded 59,430 long tons of shipping ore (see tables 4 and 5). All but one of them can be classified as a pod deposit. The largest has yielded over 14,000 long tons of shipping ore and may ultimately yield 20,000 tons, thus becoming the greatest producer of lump ore among the individual deposits in the Pacific Coast states.

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[13] Rynearson, G. A., and Smith, C. T., Chromite deposits in the Seiad quadrangle, Siskiyou County, California: U. S. Geol. Survey, Bull. 922J, p. 291, 1940.

[14] Rynearson, G. A., and Wells, F. G., Geology of the Grey Eagle and some nearby chromite deposits in Glenn County, California: U. S. Geol. Survey, Bull. 945A, fig. 1, 1944.

It is impossible to make any valid estimate of reserves in Del Norte County. Where, as is often the case in this region, solid chromite exposed over an area of a hundred square feet may not extend a foot below the surface, any estimates except of ore in sight are highly conjectural. A brief review, however, of conditions that have influenced discovery and production in the past may give a clue to what can be expected in the future.

When, in 1917, the Government issued a plea urging prospectors and miners to produce chromite, there were hundreds of prospectors in the Klamath Mountains who had scoured the range from end to end in a search for gold, and as soon as those prospectors learned what chromite looked like they could immediately go back to places where they had seen it in float or outcrops. In some places chromite outcrops projected above the ground; at High Plateau, massive chromite stood 6 feet above the surface. Mining was immediately started; those deposits that were near roads were producing in a very short time, and even deposits 10 or 15 miles away from any road were opened up. Fifty deposits were located and worked in the 18 months preceding the Armistice of 1918. When France fell in 1940, it became obvious to the miners and promoters that the price of chromite would go up. Many of the old properties were revisited and some were reopened, and 90 percent of the ore produced in the years 1940 to 1944 came from the old mines. A little prospecting was done during those years but only 20 new deposits were found, and they are credited with only about 10 percent of the production for 1940 to 1944, or 5 percent of the total production. This result indicates, first, that the deposits most easily found have been located, and second, either that few men have been available who are skilled in finding chromite deposits or else that those available have not considered it profitable to prospect such deposits.

Chromite is highly resistant to weathering and has a high density. The enclosing peridotite weathers much more rapidly, and its decomposition products are partly carried away in solution and partly reduced to light insoluble fragments that are easily washed away, while the chromite it originally enclosed lingers behind. Much of the chromite contained in the layer of rock, possibly many tens of feet thick, that has been eroded away during the recent geologic past therefore lay on the present land surface when the search for chromite began, and guided the prospectors to places where they naturally assumed that there might be chromite in place at or just below the surface. That was sometimes the case but not always; in some places the float had travelled a long way and could not easily be traced to its source. The abundance of float showed, however, that there was much chromite in the rock removed by erosion, and there is no reason to suppose that the rock removed, or that lying within, say, 50 feet of the surface is any richer than the rock lying at greater depth.

But the finding of deep-lying deposits presents problems that are as yet unsolved. Geophysical methods have not been helpful thus far in locating concealed ore in this rugged country. There is no easy way to locate deep-lying deposits, and the cost of exploration by diamond drilling or development work increases rapidly with depth. At the present time it apparently does not pay to explore ground surrounding a large pod to depths exceeding 100 feet, but ore may well extend much

*Table 2—Partial analyses of chromite from Del Norte County, California*

M. K. Carron, Analyst

| | Concentrate | | | | Ore | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cr | Fe | Cr/Fe | $Cr_2O_3$ | Cr | Fe | Cr/Fe | $Cr_2O_3$ | Chromite | $SiO_2$ |
| FGW-28-43 | 37.50 | 13.02 | 2.88 | [1]54.81 | 27.08 | 10.23 | 2.65 | 39.57 | 72.2 | ---------- |
| FGW-36-43 | 31.58 | 14.31 | 2.21 | [2]46.15 | 16.75 | 9.35 | 1.79 | 24.49 | 53.1 | ---------- |
| FGW-4-42 | 33.83 | 12.98 | 2.60 | 49.43 | 29.52 | 12.62 | 2.34 | 43.14 | 87.2 | 4.72 |
| FGW-3-42 | 34.48 | 12.43 | 2.77 | 50.38 | 32.13 | 12.24 | 2.63 | 46.98 | 93.3 | 3.08 |
| FGW-2-42 | 37.52 | 12.01 | 3.12 | 54.81 | 34.23 | 12.19 | 2.81 | 50.02 | 91.3 | 2.28 |
| FGW-1-42 | 33.31 | 13.76 | 2.43 | 48.68 | 29.52 | 12.33 | 2.39 | 43.15 | 88.6 | 4.85 |
| FGW-71-43 | 40.85 | 11.45 | 3.57 | [2]59.70 | 37.90 | 11.55 | 3.28 | 55.39 | 92.8 | ---------- |

[1] Concentrate non-magnetic.
[2] Concentrate slightly magnetic.

| | |
|---|---|
| FGW-28-43 | Lump sample from the Chrome Hill No. 1 claim, sec. 29, T. 18 N., R. 3 E. |
| FGW-11-42 | Composite grab sample from ore bin at French Hill chromite mine, NW¼ sec. 6, 16 N., R. 2. E. |
| FGW-36-43 | Grab sample from Coon Creek No. 1 claim, sec. 12, T. 16 N., R. 3 E. |
| FGW- 4-42 | Grab sample from the Big Dipper claim, SW¼ sec. 7, T. 16 N., R. 3 E. |
| FGW- 3-42 | Grab sample from the Sunrise claim, sec. 19, T. 16 N., R. 3 E. |
| FGW- 2-42 | Grab sample from Stevens No. 2 claim, sec. 28, T. 16 N., R. 3 E. |
| FGW- 1-42 | Grab sample from Muzzle Loader mine, SE¼ sec. 4, T. 15 N., R. 3 E. |
| FGW-71-43 | Grab sample from the Old Doe claim, sec. 22, T. 15 N., R. 2 E. |

*Table 3—Range in composition of ore from Del Norte County bought by the Metals Reserve Company, at Grants Pass, Oregon, during 1942 and 1943*
(Abbott Hanks Company, analysts)

| Property No. | 2 | 3 | 7 | 8 | 10 |
|---|---|---|---|---|---|
| Ore— | | | | | |
| $Cr_2O_3$ | 38.65 - 43.16 | 41.15 - 43.79 | 39.9 - Av. | 44.65 - 50.55 | 41.83 - 45.75 |
| Fe | 10.17 - 11.35 | 11.50 - 11.96 | 10.45 - Av. | 9.52 - 10.79 | 10.57 - 11.21 |
| Ratio Cr/Fe | 2.53 - 2.84 | 2.38 - 2.50 | 2.61 - Av. | 3.21 - 3.52 | 2.55 - 2.77 |
| Property No. | 11 | 12 | 13 | 14 | 17 |
| $Cr_2O_3$ | 42.68 - 45.20 | 50.5 - Av. | 48.84 - 54.98 | 39.47 - Av. | 44.83 - 51.48 |
| Fe | 10.43 - 10.97 | ------------ | 9.53 - 11.56 | 11.14 - Av. | 10.53 - 11.06 |
| Ratio Cr/Fe | 2.74 - 2.92 | 2.82 - Av. | 2.94 - 3.74 | 2.42 - Av. | 2.77 - 3.20 |
| Property No. | 18 | 19 | 28 | 32 | 35 |
| $Cr_2O_3$ | 45.91 - Av. | 44.6 - Av. | 41.16 - 46.82 | 39.96 - 41.19 | 47.8 - Av. |
| Fe | 11.34 - Av. | ------------ | 11.38 - 13.86 | 11.45 - 11.80 | ------------ |
| Ratio Cr/Fe | 2.77 - Av. | 2.48 - Av. | 2.03 - 2.63 | 2.39 | 2.77 - Av. |
| Property No. | 36 | 37 | 39 | 40 | 46 |
| $Cr_2O_3$ | 42.63 - Av. | 42.70 - 43.54 | 40.4 - Av. | 42.6 - Av. | 48.67 - 49.30 |
| Fe | 12.72 - Av. | 11.16 - 11.95 | ------------ | ------------ | 11.24 - 11.93 |
| Cr/Fe | 2.29 - Av. | 2.49 - 2.62 | 2.35 - Av. | 2.62 - Av. | 2.79 - 2.96 |
| Property No. | 50 | 51 | 52 | 65 | 66 |
| $Cr_2O_3$ | 38. - 45. | 37.31 - 41.55 | 38.03 - 39.85 | 44.03 - 49.62 | 37.40 - 47.08 |
| Fe | 2.2 - 2.8 | 11.70 - 11.99 | 11.60 - 11.70 | 11.39 - 13.53 | ------------ |
| Ratio Cr/Fe | ------------ | 2.13 - 2.43 | 2.24 - 2.33 | 2.41 - 2.96 | 2.22 - 3.23 |

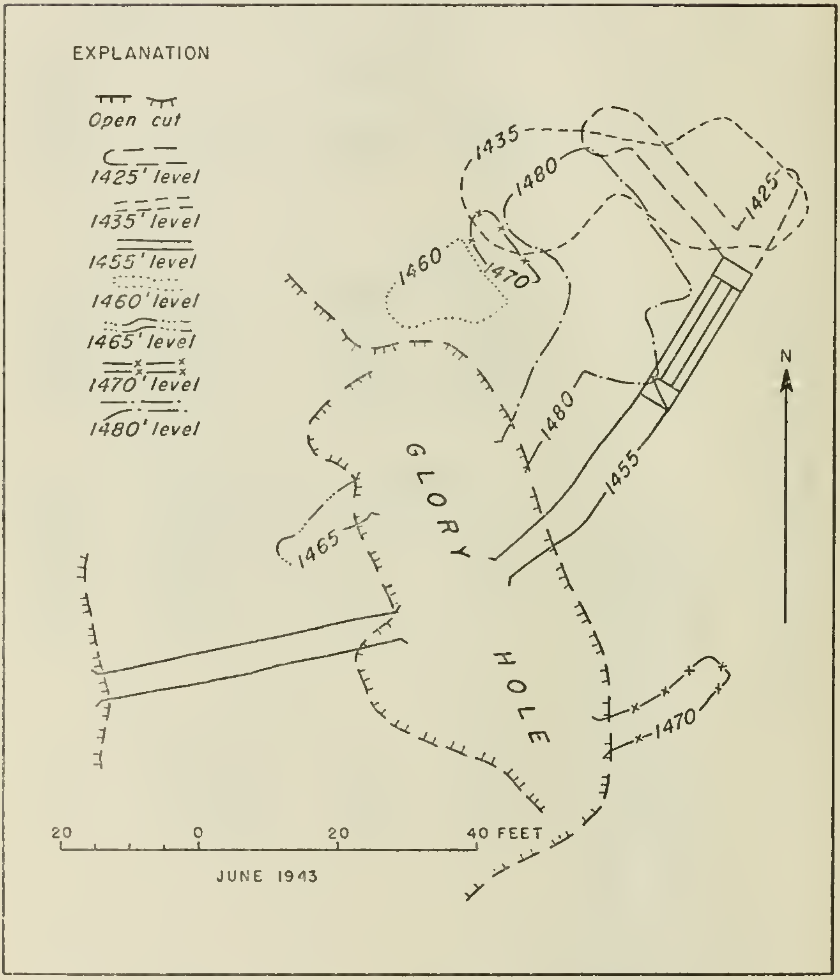

FIG. 2. Composite plan of workings in the Copper Creek mine, Del Norte County.

*Table 4—Total shipments from Del Norte County by years*

| Years | Long tons | Years | Long tons |
|---|---|---|---|
| Before 1916 | 15,850 | 1939 | 82 |
| 1917 | 2,991 | 1940 | 284 |
| 1918 | 7,056 | 1941 | 3,490 |
| 1919-1935 | none | 1942 | 4,897 |
| 1936 | 72 | 1943 | 12,958 |
| 1937 | 1,339 | 1944 | 10,411 |
| 1938 | none | | |
| | | Total known shipments | 59,430 |

deeper than that in the vicinity of the large deposits, and whenever it becomes economically feasible, exploration will be carried to greater depths. Under the pressure of war it has been impossible to do the geologic work necessary for developing geologic guides to ore, but it is hoped that such work will be done in the future. In the areas that have been thoroughly prospected there is probably as much chromite below the mine workings as has already been mined, but this chromite is not likely to be found and mined until the difficulties outlined have been met.

Del Norte County, however, still contains large areas that are underlain by peridotite but have not yet been adequately prospected, and new deposits will undoubtedly be found in some of those areas. Most of the ground in Rattlesnake Mountain, Big Red Mountain, and Ship Mountain deserves further prospecting. With the help of thorough geologic work and the necessary economic stimuli, an area that has been so little explored as Del Norte County seems likely to yield as much chromite in the future as it has in the past.

The chromite mines and prospects in Del Norte County are listed in table 6.

## PROPERTIES IN MIDDLE PERIDOTITE BELT

### Wimer Road Area

The rocks exposed on Copper Creek and in Low Divide at the head of Copper Creek are for the most part highly sheared, and the peridotite is probably cut by a major fault striking nearly north and south. Copper deposits were developed in this area in 1860.[15] The copper deposits are poorly defined, but they are all in north-trending zones of highly sheared serpentine.

### Copper Creek Chromite Mine (2)

The Copper Creek chromite mine, also known as the Low Divide or Rowdy Creek mine, is on the Copper Creek claim, patented in 1886 as Mineral Lot No. 39. The claim is in the SW¼ sec. 26, T. 18 N., R. 1 E. The mine workings, which are situated on the east slope of Copper Creek Canyon, are connected by about 2 miles of rough truck trail with Low Divide, on the Wimer road. The ore is trucked 102 miles to Grants Pass.

Mining in the Copper Creek deposit was probably begun in the early 1880's by the old Tyson Mining Company of Baltimore, Maryland. This company is said to have mined about 700 tons of ore, but it seems to have made no shipments, owing perhaps to the inaccessibility of the mine or to the decline of chromite prices which occurred at that time.

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[15] Maxson, J. H., op. cit., pp. 148-149.

*Table 5—Chromite production from Del Norte County, California, 1917-1943*

| Property | No. | 1917 | 1918 | 1919-1940 | | | 1941 | 1942 | 1943 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Year | Tons | Total | | | | |
| Bennett* | | | | | | | | | 20 | 20 |
| Big Dipper (Roar) | 37 | | | | | | | 224 | 115 | 339 |
| Big Red Mountain (Red Mountain) | 70 | | 72 | | | | | | | 72 |
| Billy Boy (Hawkins) | 47 | | | | | | (2) | | | |
| Big Buck (Deo Bros.)* | | | | | | | | | 8 | 8 |
| Big Four (Rodgers)* | | | | | | | | | 18 | 18 |
| Bonanza | 12 | | | | | | | 149 | | 149 |
| M. Boutz* | | | 140 | | | | | | | 140 |
| Buckhorn (Pac. Cr. and Mn. Sun.)* | | | | | | | 36 | | | 36 |
| Camp 7 | 37 | | (3) | | | | | | 34 | 34 |
| Chrome Hill No. 1 | 18 | | | | | | | | 20 | 20 |
| Coon Mountain Nos. 1-3 | 31 | | | | | | | | 57 | 57 |
| Copper Creek (Low Divide) | 2 | | 2,876 | | | | | 38 | 240 | 3,154 |
| Crescent | 62 | | (2) | | | (2) | (2) | (2) | (2) | |
| Crescent City No. 2 (Griffith Min. & Devel. Co.)* | | | | | | | | | 10 | 10 |
| Deleray & Rodgers | 55 | | (2) | | | (2) | (2) | (2) | (2) | |
| Dipper* | | | | | | | | | 63 | 63 |
| Eugene Brown (job lots)* | | | | | | | | 28 | | 28 |
| French Hill | 28 | 2,773 | 1,267 | (1940) | 50 | 50 | 495 | 1,439 | 8,030 | 14,054 |
| Gilmore | 56 | | (2) | | | (2) | (2) | (2) | (2) | |
| Gordon Mountain | 35 | | | | | | | | | |
| | 42 | | 179 | | | | | | | 179 |
| Grumpy* | | | | | | | 38 | | | 38 |
| High Dome | 19 | | | | | | | 275 | 20 | 295 |
| High Plateau | 13 | | 1,334 | (1937) | 1,196 | | | 1,934 | 2,444 | 8,823 |
| | | | | (1940) | 34 | 1,230 | 1,881 | | | |
| Inman No. 1 | 57 | | (2) | | | (2) | (2) | (2) | (2) | |
| Inman No. 2 | 63 | | (2) | | | (2) | (2) | (2) | (2) | |
| Inman No. 5 | 65 | | (2) | | | (2) | (2) | (2) | (2) | |
| Judy (Hicks) | 11 | | | | | | | 65 | 320 | 385 |
| K. J. Khoeery* | | 179 | | | | | | | | 179 |
| Last Chance* | | | | | | | | | 34 | 34 |
| Little Lead (Logan & Curnow)* | | | | | | | | | 21 | 21 |
| Lucky Lode | 59 | | (2) | | | (2) | (2) | (2) | (2) | |
| McClendon | 54 | | (2) | | | (2) | (2) | (2) | (2) | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| McClendon (job lots)* | | | | | | | | 12 | | 12 |
| Muzzleloader (Stevens No. 1) | 46 | | | | | | | | 169 | 169 |
| Mountain View (High Divide) (Chrome Hill) | 3 | | 360 | | | | | 10 | 225 | 595 |
| Old Doe | 66 | | (2) | | | | (2) | (2) | (2) | |
| Owl and Black Jack* | 24 | | 51 | | | | | | | 51 |
| Patterson No. 1 | 38 | | | | | | 94 | | | 94 |
| Patrick Creek (S. Smith)* | | | | | | | | 48 | | 48 |
| Pigeon Roost Spring | 60 | | (2) | | | (2) | (2) | (2) | (2) | |
| Rattlesnake Mountain | 51 to 66 | | 714 | (1940) | 100 | | 585 | 156 | 803 | 2,358 |
| Remsen, J. K.* | | | | | | | | 70 | | 70 |
| Richey, U. S., & S. J.* | | | | | | | | | 23 | 23 |
| R. M. C. (job lots)* | | | | | | | | 17 | | 17 |
| St. Patrick (Camp 8) | 39 | | (3) | | | | | 27 | | 27 |
| Section 16 | 53 | | (2) | | | (2) | (2) | (2) | (2) | |
| Smith Contract* | | | | (1940) | 100 | | | | | 100 |
| Soldiers Wells | 54 | | (2) | | | (2) | (2) | (2) | (2) | |
| Sourpuss | 58 | | (2) | | | (2) | (2) | (2) | (2) | |
| Sunrise | 40 | | | | | | 321 | [4]168 | | 489 |
| Sunset | 35 | | | (1936) | 72 | | | | | |
| | | | | (1937) | 143 | 279 | 40 | 42 | | 379 |
| | | | | (1939) | 82 | | | | | |
| Tangerine | 15 | | | | | | | | 11 | 11 |
| 3-way Metals Ltd. (job lots) | | | | | | | | 101 | | 101 |
| Toujours Gai | 17 | | | | | | | 29 | 235 | 264 |
| Victory Nos. 1 and 2 (M. Hicks) | | | | | | | | | 22 | 22 |
| White Feather | 22 | | | | | | | 65 | | 65 |
| Zinc Saddle | 30 | | (3) | | | | | | 16 | 16 |
| (Name Unknown) | 49 | | (2) | | | (2) | (2) | (2) | (2) | |
| (4 others) | | 39 | 63 | | | | | | | 102 |

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[2] Included in production from Rattlesnake Mountain claims.
[3] Included in production from Gordon Mountain claims.
[4] Includes some production from Rattlesnake Mountain claims.
* Location of source uncertain.

*Table 6—Alphabetical list of chromite mines and prospects in Del Norte County, giving old names, location, owners, and operators*

| Claim or mine name | Map No. | Location | | | Owner and shipper | Class by production* |
|---|---|---|---|---|---|---|
| | | Sec. | Twp. | Range | | |
| Alyce and Blue Jay | 21 | 23 | 18 N. | 5 E. | Jack Eggers, G. G. Shaddinger (O); W. E. Gilmore (S) | C |
| Angela | 23 | NW¼ 17 | 17 N. | 2 E. | George Wisston (O) | C |
| Apex (Goose Egg) | 34 | 8 | 16 N. | 3 E. | Albert C. Ashcroft (O) | C |
| Big Dipper (Camp 7) (Rowan) | 37 | 7 | 16 N. | 3 E. | Mrs. Floyd Peuten (O); C. H. Bennett (S) | C |
| Big Five (Inman No. 5) | 63 | SE¼ 27 | 15 N. | 2 E. | Inman Bros. (O & S) | B |
| Big Red Mountain (Red Mountain) No. 1, No. 2, No. 3 | 71<br>70<br>69 | 18 | 13 N. | 3 E. | Kenneth Deleray (O) | C |
| Billy Boy (Hawkins) (Divide) | 47 | 29 | 16 N. | 2 E. | William Hawkins (O); C. H. McClendon (S) | B |
| Black Jack | 24 | NW¼ 17 | 17 N. | 2 E. | George Wisston (O) | C |
| Black Prince | 1 | 24 | 18 N. | 1 E. | | D |
| Black Prince | 6 | 35 | 18 N. | 1 E. | | D |
| Blue Bird | 10 | 29 | 18 N. | 2 E. | J. E. Eckett, H. G. Miller, E. G. Tarbell (O & S) | B |
| Blue Jay | 21a | | | | (See Alyce) | C |
| Bonanza | 12 | 21 | 18 N. | 2 E. | Clarence Strong, Delbert O'Brien, Clifford Johnson (O & S) | C |
| Camp 7 | 37 | | | | (See Big Dipper) | B |
| Camp 8 | 39 | | | | (See St. Patrick) | C |
| Carla | 50 | 9 | 15 N. | 2 E. | C. Stevens, J. Wilson (O & S) | C |
| Chrome Hill No. 1 | 18 | 30 | 18 N. | 3 E. | David Webb (O); J. W. Eggers (S) | C |
| Coonean | 33 | 12 | 16 N. | 2 E. | | C |
| Coon Creek No. 1 | 32 | 12 | 16 N. | 2 E. | C. H. McClendon (O & S) | C |
| Coon Mountain group | 31 | 11 | 16 N. | 2 E. | Bert McBride, (O); C. H. McClendon (S) | C |
| Contact | 49 | 29 | 16 N. | 2 E. | C. H. Bennett (O) | C |
| Copper Creek (Low Divide) | 2 | 26 | 18 N. | 1 E. | Tyson Chrome Mines, Ltd. (O); C. A. Gillis, G. Brandis (S) | A |
| Crescent | 62 | 27 | 15 N. | 2 E. | Inman Bros. (O & S) | C |
| Crescent City beach deposits | 72<br>73 | 34<br>2, 11 | 16 N.<br>15 N. | 1 W. | | D |
| Cuneo | 52 | Middle 16 | 15 N. | 2 E. | Hammond Lumber Co. (O); L. J. Cuneo & J. J. Rodgers (S) | B |
| Darnell | 35 | | | | (See Sunset) | B |

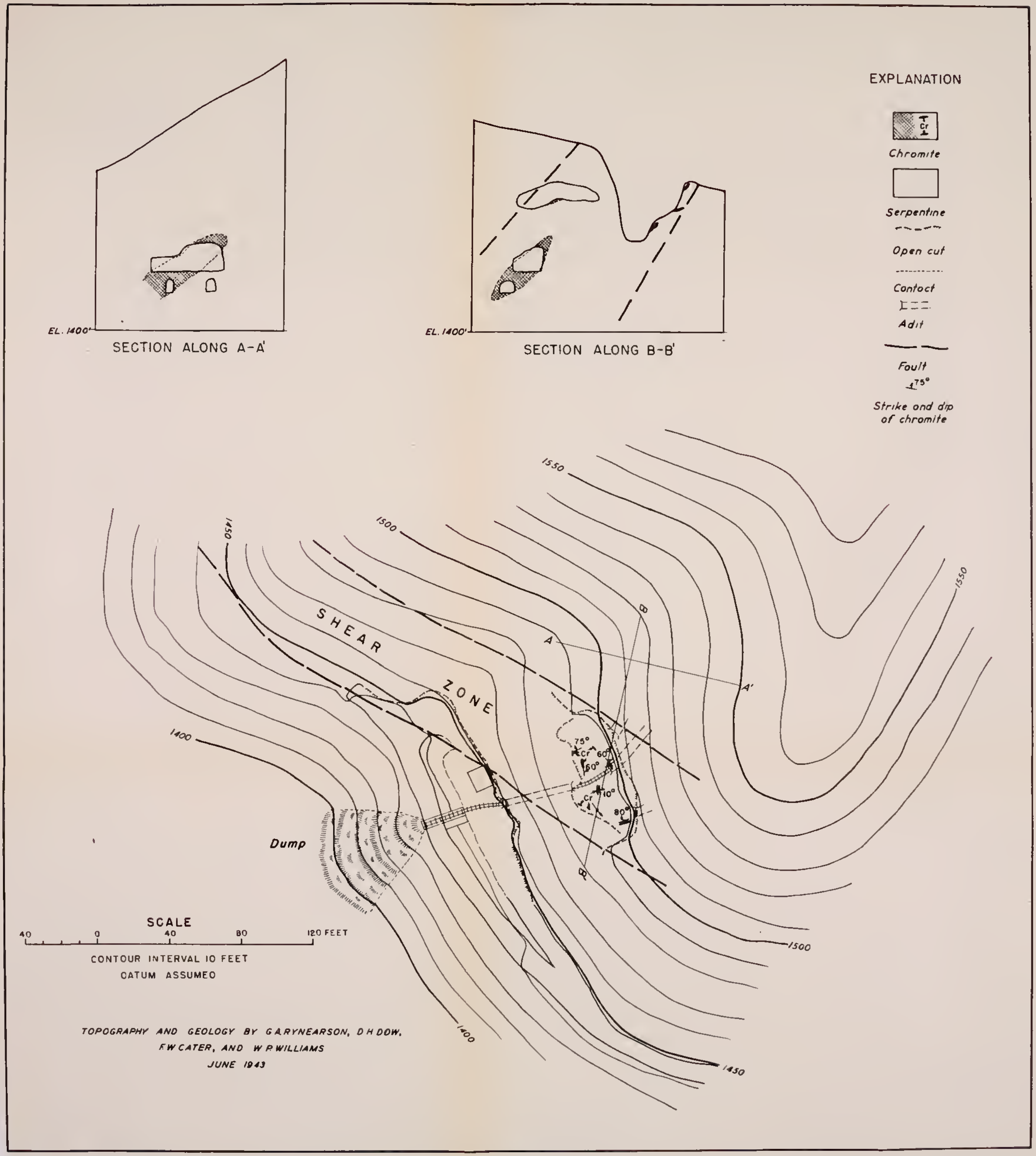
| | | | | | | |
|---|---|---|---|---|---|---|
| Deleray & Rodgers | 55 | 16 | 15 N. | 2 E. | Hammond Lumber Co. (O); Arthur Deleray & J. J. Rodgers (S) | C |
| Divide | 47 | | | | (See Billy Boy) | B |
| Ebon | 20 | 17 | 18 N. | 5 E. | J. W. Eggers (O & S) | C |
| Fairview | 27 | W½ 30 | 17 N. | 2 E. | | D |
| Fourth of July | 48 | 29 | 16 N. | 2 E. | C. H. McClendon (O & S) | C |
| French Hill | 28 | NE¼ 6 | 16 N. | 2 E. | Tyson Chrome Mines, Ltd. (O & S) | A |
| Gilmore | 41 | 30 | 16 N. | 3 E. | | |
| Gilmore | 56 | 17 | 15 N. | 2 E. | W. E. Gilmore (O) | C |
| Gooch | 5 | 1 | 17 N. | 1 E. | H. W. Gooch (O) | D |
| Goose Egg | 34 | | | | (See Apex) | C |
| Goose Creek | 67 | 22 | 15 N. | 2 E. | C. H. McClendon (O) | D |
| Grumpy | 42 | 30 | 16 N. | 3 E. | C. H. Bennett (O & S) | C |
| Hawkins | 47 | | | | (See Billy Boy) | B |
| High Dome | 19 | 20 | 18 N. | 3 E. | Edward Cook (O); C. H. Bennett & J. K. Remsen (S) | B |
| High Plateau | 13 | 28 | 18 N. | 2 E. | Eugene Brown (O & S) | A |
| Hole in the Ground | 7 | 12 | 18 N. | 2 E. | Pauline Deo, Al Falkins (O); Al Falkins (S) | C |
| Inman No. 1 | 57 | | | | (See Cuneo) | B |
| Inman No. 2 | 61 | 21 | 15 N. | 2 E. | Inman Bros. (O & S) | C |
| Inman No. 5 | 65 | | | | (See Big Five) | B |
| Judy No. 1, No. 3, No. 4, (Hicks) | 11 | 29 | 18 N. | 2 E. | Murphy Hicks (O); Pacific Mining Co. (S) | B |
| Logan | 16 | 17 | 18 N. | 3 E. | Richard Noue & James C. Curnow (O); George Logan (S) | C |
| Lone Grave No. 1 | 43 | 32 | 16 N. | 3 E. | William Stevens & R. R. Stevens (O) | D |
| Lone Grave No. 2 | 44 | NW¼ 33 | 16 N. | 3 E. | William Stevens & R. R. Stevens (O) | D |
| Low Divide | 2 | | | | (See Copper Creek) | C |
| Lucky Lode | 59 | 16 | 15 N. | 2 E. | | C |
| Long Hike, Dipper, High Plateau | 13 | 28 | 18 N. | 2 E. | Eugene Brown (O) | C |
| Margy | 26 | 30 | 16 N. | 3 E. | | C |
| McClendon | 54 | | | | (See Soldiers Well) | C |
| Midnight | 66 | 15 | 15 N. | 2 E. | | D |
| Mountain View (High Divide) | 3 | E½ W½ 34 | 18 N. | 1 E. | Tyson Chrome Mines, Ltd. (O & S) | A |
| Mud Spring | 68 | 33 | 15 N. | 2 E. | C. H. McClendon (O) | C |
| Muzzle Loader (Stevens) | 46 | SE¼ 4 | 15 N. | 3 E. | Robert R. Stevens, W. M. Stevens (O); J. K. Remsen, C. H. Bennett (S) | B |
| Niggerhead | 25 | SW¼ 17 | 17 N. | 2 E. | | D |
| Old Doe | 4 | 22 | 15 N. | 2 E. | Inman Bros. (O & S) | B |
| One-Eyed Jack, No. 1, No. 2, No. 3 (Zoer) | 4 | 35 | 18 N. | 1 E. | | C |
| Patterson No. 1 | 38 | 18 | 16 N. | 3 E. | C. H. Bennett & J. K. Remsen (O & S) | C |
| Pigeon Roost Spring | 60 | 21 | 15 N. | 2 E. | Albert Inman, Homer Inman, J. E. Inman (O & S) | C |
| Pine Flat | 8 | 6 | 18 N. | 2 E. | Charles Deo (O) | C |

*Table 6—Alphabetical list of chromite mines and prospects in Del Norte County, giving old names, location, owners, and operators—Continued*

| Claim or mine name | Map No. | Location | | | Owner and shipper | Class by production* |
|---|---|---|---|---|---|---|
| | | Sec. | Twp. | Range | | |
| Rattlesnake | 51 | 17 | 15 N. | 2 E. | John Smith (O); T. J. Rodgers (S) | C |
| Richey | 14 | 5 | 18 N. | 3 E. | S. J. Ricbey & V. I. Richey (O & S) | C |
| Rowan | 37 | | | | (See Big Dipper) | C |
| St. Patrick (Camp 8) | 39 | W½ 19 | 16 N. | 3 E. | J. K. Remsen, C. H. Bennett (O & S) | C |
| Section Sixteen | 53 | SW¼ 16 | 15 N. | 2 E. | Hammond Lumber Co. (O) | B |
| Skyline | 9 | SE¼ 30 | 18 N. | 2 E. | J. Eckett, H. G. Miller, E. G. Tarbell, J. C. Rodgers (O & S) | C |
| Soldiers Well | 54 | 17 | 15 N. | 2 E. | | C |
| Sourpuss | 58 | 16 | 15 N. | 2 E. | | C |
| Star | 29 | 31 | 17 N. | 2 E. | Elmer Smith (O) | D |
| Stevens No. 2 | 45 | SW¼ 28 | 16 N. | 3 E. | Wm. Stevens, R. Stevens (O) | D |
| Stevens No. 6 | 43 | | | | Wm. Stevens (O) | D |
| Sunrise | 40 | 19 | 16 N. | 3 E. | W. E. Gilmore (O & S) | B |
| Sunset (Darnell) | 35 | SW¼ 5 | 16 N. | 3 E. | C. A. Bennett (O & S) | B |
| Tangerine | 15 | NW¼ 18 | 18 N. | 3 E. | David Webb, H. T. Borgman, W. J. Stillwell (O) | D |
| Thursday Evening | 38 | 18 | 16 N. | 3 E. | C. H. Bennett (O & S) | C |
| Toujours Gai | 17 | NW¼ 19 | 18 N. | 3 E. | David Webb (O); F. M. Linkhart & E. H. Messenger (S) | B |
| Tyson Chrome Mines, (Ltd.) | (28) | | | | (See French Hill and Mountain) | A |
| White Feather | (22) | SW¼ 4 | 17 N. | 5 E. | Baker Bros. & Owen Jones (O & S) | C |
| Zinc Saddle | 30 | 25 | 17 N. | 2 E. | Oliver Linn (O); J. H. McDaniels (alleged shipper) | C |
| Zoar | 4 | | | | (See One-Eyed Jack) | C |

* A, 1000 long tons or more; B, 150-1000 long tons; C, less than 150 long tons; D, no ore shipped.

W. BU
O



CONTOUR INTERVAL 10 FEET
DATUM ASSUMED

*TOPOGRAPHY AND GEOLOGY BY G. A. RYNEARSON, D. H. DOW, F. W. CATER, AND W. P. WILLIAMS*
*JUNE 1943*

GEOLOGIC MAP AND SECTIONS OF THE COPPER CREEK MINE, DEL NORTE COUNTY, CALIFORNIA

In 1917 and 1918 the American Exploration and Construction Company, operating under a lease from the Tyson Estate, built a road to the mine and shipped 2876 long tons of ore, but it abandoned the property when chromite prices declined at the close of World War I. The mine then lay idle until 1942, when Tyson Chrome Mine, Ltd., of 406 Montgomery Street, San Francisco, California, got title to it and leased to C. A. Gillis, W. E. Gillis, and G. Brandi. These men mined and shipped 239 long tons of ore, containing, on the average, 41.2 percent of $Cr_2O_3$ and having a Cr/Fe ratio of 2.56, but they suspended operations in the latter part of 1943, when C. A. Gillis was fatally injured by a rock fall in the underground workings.

The deposits have been briefly described by Caldwell [16], Logan [17], and Diller [18]. Five days of field work were spent at the mine during June, July, and August 1943, by F. W. Cater, Jr., D. H. Dow, G. A. Rynearson, and W. P. Williams, who prepared the maps forming plate 2 and figure 2. The late C. A. Gillis and his associates generously cooperated with the field party and supplied valuable production figures.

The Copper Creek chromite deposit lies 5000 feet south of the point where the western margin of the peridotite changes its course from northeast to nearly north. The peridotite is considerably sheared, and in the area mapped in detail (see pl. 2) it is crossed by a zone of intense shearing that trends N. 65° E. The boundaries of this zone as shown on the map are only approximate, because the zone is not sharply defined; the intensity of the shearing decreases gradually outward from the main part of the zone. All the ore bodies lie within the strongly sheared rock.

At least three large ore bodies, or groups of ore bodies, have been mined on the property, one from the glory hole and the others from the underground workings to the northeast. The ore body mined from the glory hole is said to have had a northerly strike and an easterly dip of 60°, and to have been from 6 to 10 feet thick and 60 feet long. It may have consisted of several masses of chromite close together. Several relatively small lenses or stringers of ore have been mined from small stopes in the walls of the glory hole, where numerous irregular stringers and small patches of ore may still be seen.

The ore mined from the main underground workings came from two or three rather large pods or lenses of chromite. Part of a lens striking N. 70° W., dipping 50° E., and plunging northwest is exposed in the lowest levels and was being worked when the mine was abandoned in 1943. Another ore body has been mined from higher stopes that are now badly caved. The attitude of the upper body could not be determined directly, but the shapes of the openings indicate that it was similar to that of the lower body. Several smaller lenses and stringers of ore appear to have been mined from a southwestern extension of the upper stope, under the northern end of the glory hole.

The ore in the Copper Creek deposits consists of medium-grained chromite with only a little interstitial serpentine and talc. The $Cr_2O_3$ content ranges from 38 to 45 percent, and the Cr/Fe ratio averages

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[16] Caldwell, F. B., Unpublished reports of the California State Council of Defense, 1918.

[17] Bradley, W. W., and others, Manganese and chromium in California: California Min. Bur. Bull. 76, pp. 108, 125-126, 1918.

[18] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey Bull. 725, p. 31, 1921.

In 1917 and 1918 the American Exploration and Construction Company, operating under a lease from the Tyson Estate, built a road to the mine and shipped 2876 long tons of ore, but it abandoned the property when chromite prices declined at the close of World War I. The mine then lay idle until 1942, when Tyson Chrome Mine, Ltd., of 406 Montgomery Street, San Francisco, California, got title to it and leased to C. A. Gillis, W. E. Gillis, and G. Brandi. These men mined and shipped 239 long tons of ore, containing, on the average, 41.2 percent of $Cr_2O_3$ and having a Cr/Fe ratio of 2.56, but they suspended operations in the latter part of 1943, when C. A. Gillis was fatally injured by a rock fall in the underground workings.

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The Copper Creek chromite deposit lies 5000 feet south of the point where the western margin of the peridotite changes its course from northeast to nearly north. The peridotite is considerably sheared, and in the area mapped in detail (see pl. 2) it is crossed by a zone of intense shearing that trends N. 65° E. The boundaries of this zone as shown on the map are only approximate, because the zone is not sharply defined; the intensity of the shearing decreases gradually outward from the main part of the zone. All the ore bodies lie within the strongly sheared rock.

At least three large ore bodies, or groups of ore bodies, have been mined on the property, one from the glory hole and the others from the underground workings to the northeast. The ore body mined from the glory hole is said to have had a northerly strike and an easterly dip of 60°, and to have been from 6 to 10 feet thick and 60 feet long. It may have consisted of several masses of chromite close together. Several relatively small lenses or stringers of ore have been mined from small stopes in the walls of the glory hole, where numerous irregular stringers and small patches of ore may still be seen.

The ore mined from the main underground workings came from two or three rather large pods or lenses of chromite. Part of a lens striking N. 70° W., dipping 50° E., and plunging northwest is exposed in the lowest levels and was being worked when the mine was abandoned in 1943. Another ore body has been mined from higher stopes that are now badly caved. The attitude of the upper body could not be determined directly, but the shapes of the openings indicate that it was similar to that of the lower body. Several smaller lenses and stringers of ore appear to have been mined from a southwestern extension of the upper stope, under the northern end of the glory hole.

The ore in the Copper Creek deposits consists of medium-grained chromite with only a little interstitial serpentine and talc. The $Cr_2O_3$ content ranges from 38 to 45 percent, and the Cr/Fe ratio averages about 2.5. Except where sheared, the chromite is black and has a submetallic luster. Crusts of magnesite and aragonite line open cracks in the ore and the serpentine. The ore breaks cleanly from the wall rock, the contacts being sheared and slickensided. The difference in attitude of the ore bodies may be due to the intense shearing that the enclosing serpentine has undergone.

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[16] Caldwell, F. B., Unpublished reports of the California State Council of Defense, 1918.

[17] Bradley, W. W., and others, Manganese and chromium in California: California Min. Bur. Bull. 76, pp. 108, 125-126, 1918.

[18] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey Bull. 725, p. 31, 1921.

Little ore remains either in the glory hole or in the upper parts of the underground workings. There is probably a few hundred tons of ore in and below the lower workings, but mining it in this heavy, caving ground would be dangerous and costly. Deeper-lying ore bodies might be found by diamond drilling from the surface or by driving a long adit eastward from a point below the end of the road, but there is no basis other than the size of ore bodies already mined for judging beforehand whether any ore that might be found would repay the cost of exploration.

### Mountain View (High Divide) Mine (3)

The Mountain View or High Divide mine is a mile southwest of the Copper Creek mine in the E½ sec. 33 and the W½ sec. 34, T. 18 N., R. 1 E., (see pl. 1). The main workings are at an elevation of about 2450 feet, on the summit of a flat-topped ridge. The ore is trucked 7.4 miles over graded dirt and gravel roads to the town of Smith River, and thence 91 miles on a paved highway to Grants Pass. Prior to 1936, some of the ore was loaded on small coastal steamships, part of it at the mouth of Smith River and part of it at Crescent City, which is farther away but has better harbor and docking facilities.

The property consists of three patented claims, known as the Mountain View Nos. 1, 2, and 3 claims (Mineral Lots Nos. 40, 41, and 38), and one unpatented claim located as the Tyson No. 1. All these claims are now owned and worked by Tyson Chrome Mines, Ltd.

The deposits have been briefly described by Caldwell[19], Logan[20], Diller[21], and Maxson[22]. Seven days of field work during June and August 1943 were devoted to this property by G. A. Rynearson, F. W. Cater, Jr., D. H. Dow, and W. P. Williams. The deposits on the Mountain View No. 3 claim (pl. 3) were mapped in detail, but no detailed mapping was done on the other claims, because a brief examination of the largest of the other deposits—the one on the Mountain View No. 2 claim—indicated that all of them were relatively unimportant.

Although chromite had been recognized in the district in the early 1860's, it was about 1869 before the now defunct Tyson Mining Company of Baltimore, Maryland, first began mining the Mountain View ores. Little is recorded about the ore produced in these early operations, but most of it was probably mined before 1890. In 1918 the American Exploration and Construction Company, operating under a lease from the Tyson Estate, attempted to reopen the old workings, but the production credited to this company for that year includes ore from several other deposits in northern California, and there is no way of knowing how much, if any, was taken from the Mountain View mine. The property was idle from 1918 to 1942, when Tyson Chrome Mines, Ltd. acquired the title and began exploration and development.

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[19] Caldwell, F. B., Unpublished reports of the California State Council of Defense, 1918.

[20] Bradley, W. W., and others, Manganese and chromium in California: California Min. Bur. Bull. 76, pp. 108, 124-126, 1918.

[21] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey Bull. 725, p. 31, 1921.

[22] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwesternmost California: California Jour. Mines and Geology, vol. 29, p. 156, 1933.

Estimates of the amount of ore taken from the deposits on the Mountain View No. 3 claim prior to 1942 range from a few thousand tons to 25,000 tons. During the present investigation an attempt was made to arrive at a more definite estimate, by subtracting the volume of waste in fills and dumps from the total volume of the workings. The open and filled areas of the underground workings shown in plate 3 were measured with a planimeter. It was assumed that solid rock would have 60 percent of the volume of the same rock when broken, and that there would be 9 cubic feet of unbroken ore to a long ton. It was calculated that the amount of ore extracted could not have been more than 8,750 long tons. Included in this figure are the 265 long tons of ore shipped during 1942 and 1943, which, on the average, contained 41.8 percent of $Cr_2O_3$ and had a Cr/Fe ratio of 2.43. The ore produced during the earlier operations is said to have contained 42 to 45 percent of $Cr_2O_3$.

All the ore bodies in the area mapped are enveloped by a roughly tabular mass of dunite which has an exposed length of about 520 feet and a maximum thickness of about 25 feet. Along the greater part of its length the mass strikes about N. 55° W. and dips 50° to 75° NE., but there are local variations of attitude due to warping and irregularity of shape, and the outcrop bends westward at the northwest end.

Faults and shear zones were noted elsewhere in the district, though there is a notable lack of strong faulting in the area mapped. There is, however, well developed sheeting and jointing. The sheeted structure is believed to represent flowage or fracture, or both, prior to complete consolidation of the peridotite. The general attitude of the sheeting is nearly the same as that of the large ore-bearing dunite mass. There are local variations in the attitude of the sheeting planes, but in general they strike about N. 40° W. and dip about 65° NE. There are two systems of joints, best developed in the saxonite; both strike northeastward, but one dips northwest and the other southeast. A strike of N. 40° E. and a dip of 50° NW. is typical for one system and a strike of N. 50° E. and a dip of 55° SE. is typical for the other.

Since most of the ore has been extracted and only parts of the old workings are accessible, the following description of the deposits involves some guessing with regard to the shape, size, and distribution of the ore bodies. The workings that could be entered have stood remarkably well, considering that they were in large part opened more than 50 years ago. The walls of those that have been flooded are covered with a thick layer of mud, which obscured many of the details of the geology. An attempt to reconstruct the ore bodies is shown on plate 3, parts of which are generalized for the sake of simplicity.

On the Mountain View No. 3 claim there are three major groups of ore bodies, all of them enclosed in the large mass of dunite. All the ore bodies are roughly conformable in strike and dip with the enclosing mass, and all plunge northwestward at angles of 20° to 35°.

The chromite forms pod-shaped masses and irregular stringers in the dunite or in serpentine derived from it. All the ore contains a little serpentine interspersed between the chromite grains, and some contains enough to lower its grade appreciably. The borders of the larger and richer ore bodies are sharply defined, and in most places there has been some movement along the walls, but the smaller and lower-grade ore bodies, especially the irregular stringers, tend to grade into the wall rock.

Most of the production of the mine has come from the southeastern group of ore bodies. This group is mostly mined out, but it can be seen to have consisted of at least two large ore bodies. There is some indication that what is shown on plate 3 as the larger really comprised two distinct bodies, and it is also possible that there was a small ore body in the space now occupied by the small pit just south of the main shaft. These ore bodies apparently were pod-shaped and overlapped each other slightly. Ore is said to have projected above the surface in one or more bold outcrops, but the only ore now showing at the surface consists of a few very small stringers in the wall rock. Remnants of the ore bodies still can be seen at a few places in the underground workings. All that remains of the southernmost ore body is a thin slab of ore 1 to 2.5 feet thick, exposed in the floor on the hanging-wall side of the stope. How much ore, if any, remains below the bottom of the main shaft could not be ascertained because that area was flooded. Part of the northernmost ore body also is left in the floor, walls, and northwest face of the stope. In the latter part of 1943, after the mine was mapped, C. A. Gillis leased the southeastern group of ore bodies and mined 38 tons of ore, most of which probably came from those parts of the northernmost body that are shown in sections I and J, plate 3. The extent of the workings indicates that this group of ore bodies yielded about 7300 long tons of ore, and its indicated reserves are only about 100 long tons.

The ore bodies in the northwestern group are highly irregular; they consist of a series of flat-lying stringers of both disseminated and nearly massive chromite, underlain by a steeply inclined tabular lens of high-grade ore. The ore bodies are so arranged that a cross-section of the group is roughly T-shaped. The flat-lying stringers were probably connected in some places with the steeply inclined lens, though no such connections were actually seen. The ore in the lens is in sharp contact with the wall rocks and breaks cleanly from them, but the ore in the stringers grades into the wall rock and contains small included masses of serpentine, which must be sorted out to keep the $Cr_2O_3$ content up to 40 percent.

The stopes southeast of the shaft are mostly filled with waste, but the walls of their open parts appear to have outlined the ore bodies. Part of a steeply inclined lenticular ore body still remains in the floor of the level at 2432 feet elevation, and its lower edge can be seen in the southeast wall of the shaft. As the floor of the stope is covered with waste, it is impossible to see whether or not this ore body extends any lower. Stoping in the area northwest of the shaft was largely confined to the flat-lying ore bodies, which plunge beneath the floor of the stope at its northwest end. The thin stringer of ore in the lower drift may be an isolated mass, or it may represent the lower edge of the ore bodies exposed in the upper workings. A raise which the operators plan to put up between the two levels should determine the relations between the upper and the lower occurrences of ore.

The extent of the upper workings indicates that the amount of ore mined from the northwestern group of ore bodies was about 750 long tons, 187 tons of which was produced in 1943. The $Cr_2O_3$ content of the ore recently mined ranged from 41 to 46 percent and averaged 42 percent; the average Cr/Fe ratio was 2.46. Indicated reserves above the level at 2413 feet are not more than about 40 long tons. An estimate of reserves below this level is not justified until the above-mentioned raise has been completed, but they do not seem likely to exceed 500 tons.

The central group of ore bodies is developed mainly by a large open pit. A shaft is said to have been sunk on ore to a depth of about 25 feet below the bottom of the pit, and there may be a drift or stope at the bottom of this shaft, but as the bottom of the pit is filled with waste and one end is flooded, any workings that may lie below it are probably caved or filled.

The only ore now exposed in this pit consists of two small, irregular stringers of chromite in the dunite of the hanging wall on the northeast side of the pit. The shape of the pit is assumed to be about the same as that of the ore body, or group of ore bodies, that was mined. Most of the mining of this group was done during the early operations, but in 1942 about 20 tons of ore was mined from the south side of the pit and about 20 tons from the northwest end. According to the operators, the ore body at the northwest end of the pit plunged northwest like the other ore bodies in the deposit.

Another ore body included in the central group is partly exposed by a small, shallow pit just northwest of the southeast group. Only the very top of this ore body appears to have been uncovered; the ore seen is decomposed and mixed with red clay and soil, and is not sufficiently exposed to indicate whether or not it is more than a small stringer in the weathered peridotite. It is, however, in the only large unexplored part of the deposit, and further work at this place may lead to the discovery of an important ore body or group of ore bodies.

In June and July of 1942 the present operators drilled three diamond-drill holes on the Mountain View No. 3 claim. One hole was not driven as far as planned and the other two showed no ore. In July and August 1944, the company put in three more diamond-drill holes, which are shown on plate 3. All three were started from the northeast side of the ore zone and pointed at right angles to its trend, in order to cut across this zone in depth. Hole No. 1 entered barren dunite 39 feet vertically below the surface. Hole No. 2, about 140 feet to the northwest, entered barren dunite about 126 feet vertically below the surface. Hole No. 3, drilled between the southeastern and northwestern ore bodies, penetrated a broken zone of barren dunite 65 feet vertically below the surface.

### One-Eyed Jack Nos. 1, 2, and 3 (Zoar) (4)

Several trenches have been dug on narrow stringers and small bunches of chromite in the saddle at Low Divide, in sec. 35, T. 18 N., R. 2 E. Those examined gave little evidence of having yielded more than a ton or so of ore. Maxson [23], however, in reporting on one of those owned by Frank Zoar in 1930, made the following statement:

> "The ore occurred in a vein 8 to 10 inches wide and as nodules in serpentine. About 50 tons of 54 percent ore were removed during the war."

When the property was visited in 1942 the ore had been hauled away and the trench was caved.

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[23] Maxson, John, op. cit., p. 156, 1933.

### Gooch Claim (5)

In October 1944, H. W. Gooch held a claim in the NW¼ sec. 1, T. 17 N., R. 1 E. and the NW¼ sec. 6, T. 17 N., R. 1 E., located on the west slope of the North Fork of Smith River and extending to the head of East Fork of Hardscrabble Creek. The claim contains at least two old openings, probably made during the first World War, but nothing could be learned as to who had formerly owned the claim or as to what it had produced. There is a caved shaft 3 feet square along the east side of Low Divide trail, about 1.3 miles from the Wimer road and at an altitude of 1980 feet. The dump consists of sheared, serpentinized dunite, and its size indicates that the shaft may have been about 50 feet deep. No chromite was seen. A rough truck trail 1.3 miles long leads from the shaft to the Wimer road, and a quarter of a mile of steep trail leads down from the shaft to a bench at an altitude of 1875 feet on the west side of the North Fork of Smith River. Whether this is an erosional bench or a landslide bench is not clear. About 25 feet above the bench is a depression trending S. 70° W. and about 50 feet long, which apparently marks the site of a caved adit. The dump would indicate an adit of about this or greater length, and consists of partially serpentinized dunite. About 300 feet to the north-northwest is a recent bulldozer cut, which is about 30 feet long and 5 feet deep but has not been cut down to bedrock, which is partially altered saxonite. No ore was seen here.

### Hole in the Ground Area

The trend of the contact between the peridotite and the Franciscan sediments turns from south-southwest to about southwest in a basin, at the confluence of four short streams, that is called the Hole in the Ground. The peridotite is here intensely sheared, and is altered to the whitish slickentite characteristically produced where peridotite is sheared into very small fragments and then weathered. Some chromite diggings (deposit No. 7) were seen on top of a south-trending ridge 2000 feet east of Hole in the Ground. They are at an altitude of 2100 feet, in sec. 12, T. 18 N., R. 2 E. It is said that prior to 1935 this area was held as the Lucky Queen gold claim, and that some chromite had been mined and piled by the owner. In October 1942, 43.13 long tons of ore were delivered to the Metals Reserve stockpile at Grants Pass in the name of Al Falkins, and it was reported that the ore was jointly owned by Falkins and Mrs. Pauline Deo. The ore assayed 39.9 percent $Cr_2O_3$, 10.45 percent Fe, and 7.16 percent $SiO_2$, and had a Cr/Fe ratio of 2.61.

Further east, on Pine Flat Mountain, is another chromite deposit (No. 8), said to be owned by George Deo. This property is in sec. 6, T. 18 N., R. 2 E., at an altitude of 2800 feet. About 8 long tons of chromite ore is said to have been mined from this deposit.

### High Plateau Area

The High Plateau area, which is about 22 square miles in extent, lies east of the North Fork of Smith River, between Smith River on the south and Diamond Creek on the north. It is on a tableland 2500 to 3300 feet above sea level, which falls off precipitously one to two thousand feet to the surrounding streams. A short ravine, called Peridotite Canyon, divides this tableland into Low Plateau on the north and High Plateau Mountain on the south. Most of the production has come from Low Plateau. Short, steep gulleys cut the sides of the canyons of the main streams. The upland surface is without perennial streams, and the few springs all run dry when the summer drought is unusually prolonged, making it necessary to haul water from High Plateau Creek, a distance of 6 miles. During the winter months the rainfall is sufficient to supply all mining needs.

All of this area is underlain by peridotite, which is well exposed on the walls of the canyons and forms large blocks projecting through the scanty soil on the upland. Most of the rock is medium-grained saxonite containing from 10 to 20 percent enstatite, crystals of which roughen the weathered surface. Many irregular masses of dunite are enclosed in the saxonite, but no large areas of this rock have been seen. Except where the peridotitic rocks are sheared they are not greatly serpentinized.

High Plateau can be reached from O'Brien, Oregon, which is on Highway 199 and 40 miles southwest of Grants Pass, the shipping point for this area. A graded Forest Service road, called the Wimer road, runs 17 miles westward from O'Brien to the valley of Diamond Creek, where a branch turns off southward to High Plateau. About 7½ miles from the turnoff, this road is joined by spurs to the High Plateau and other mines. The southern part of the road is very steep, and even the Wimer road is impassable during wet weather.

On Low Plateau are five deposits, the High Plateau (13), Bonanza (12), Judy (11), Bluebird (10), and Skyline (9), that have shipped over 100 long tons of ore apiece, the High Plateau having shipped several thousand tons. On High Plateau Mountain are several small deposits from which a few tons have been mined, and on the south end of this mountain there are several occurrences of chromite on which no work has been done.

### High Plateau Mine (13)

The High Plateau mine, which produced the highest-grade ore that has come from Del Norte County and is second only to the French Hill mine in amount of chromite produced, is in sec. 28, T. 18 N., R. 2 E., 28 miles by dirt road from O'Brien, Oregon. It is on the north side of Peridotite Canyon, about 250 feet below the top of the ridge and at an altitude of 2600 feet. Wells examined this mine in 1939, and it has been visited once or twice every year since then by members of the Geological Survey. Flint mapped the property in December 1942, and Cater re-mapped it in August 1944.

This deposit has been previously described or mentioned by Diller [24], Bradley [25], Maxson [26], and Allen [27].

*History and Production.* A claim containing a bold outcrop of massive chromite was located in 1917 by H. H. Morrell and John Hester. They leased the claim to Adams and Maltby, who mined and shipped 1334 long tons of ore in 1918. The property was abandoned after the Armistice and lay idle until 1933, when Eugene Brown of O'Brien,

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[24] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey Bull. 725, pp. 31-32, 1921.

[25] Bradley, W. W., and others, Manganese and chromium in California: California Min. Bur. Bull. 76, pp. 130-131, 1918.

[26] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwesternmost California: California Jour. Mines and Geology, vol. 29, pp. 155-156, 1933.

[27] Allen, J. E., Geological investigation of the chromite deposits of California: California Jour. Mines and Geology, vol. 37, pp. 117-118, 1941.

Oregon, filed on it, calling it the High Plateau claim. In 1941 he located the Addition claim, adjoining the High Plateau claim on the north.

Mr. Brown began to ship ore in 1937. This ore and that shipped previously all came from the footwall block of the deposit, which ended against a fault. In 1940 Mr. Brown found the hanging-wall block of ore, and has been shipping chromite from the deposit since 1941.

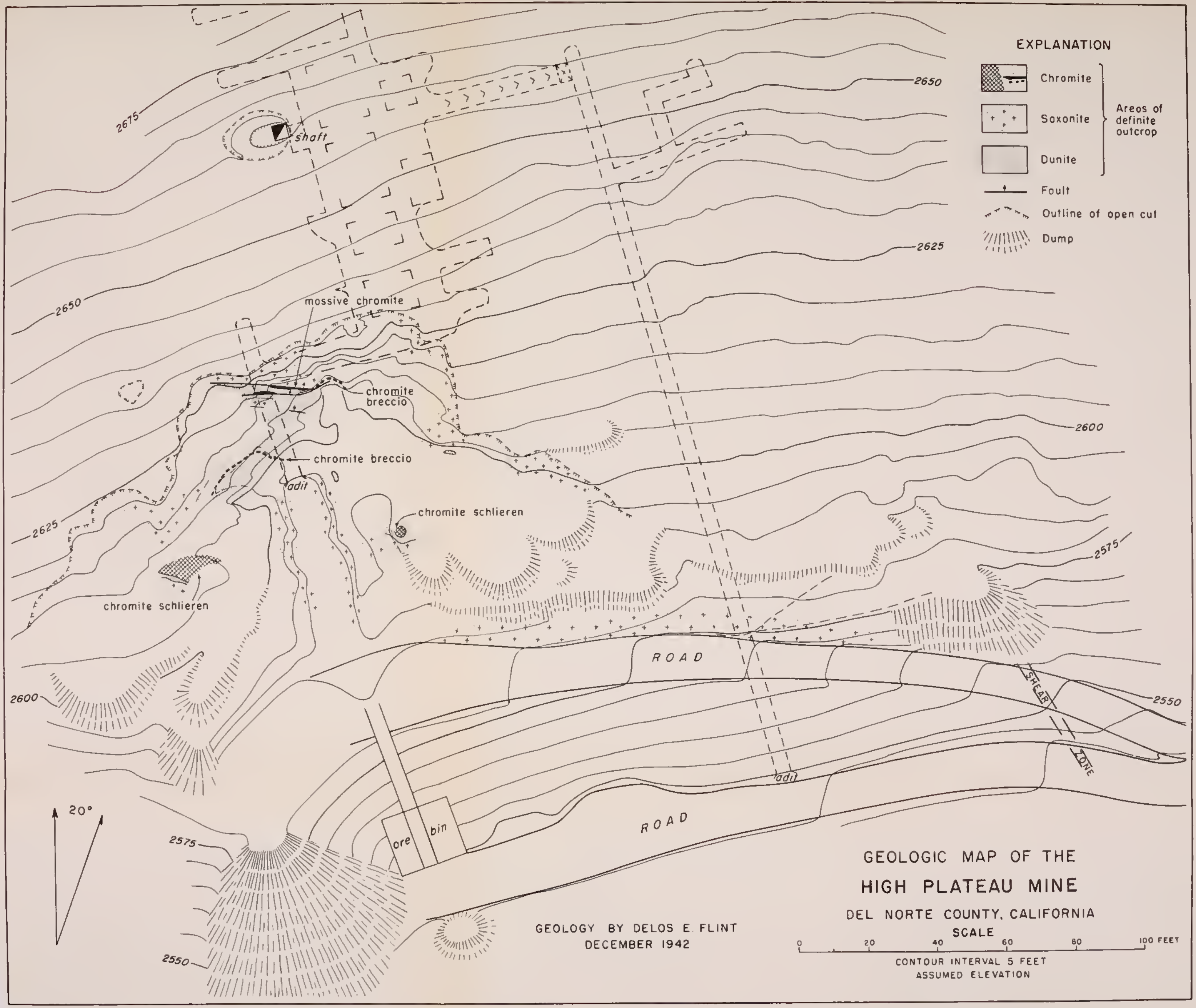
*Shipments from the High Plateau mine*

| *Year* | *Long tons* | *Year* | *Long tons* |
|---|---|---|---|
| 1918 | 1334 | 1942 | 1908 |
| 1937 | 1196 | 1943 | 2444 |
| 1940 | 34 | 1944 | 2263 |
| 1941 | 1881 | Total | 11,060 |

*Geology.* Most of the peridotite of Low Plateau is an olivine-rich saxonite, containing scattered clots of enstatite crystals in an even-grained groundmass of olivine. All the saxonite is at least slightly serpentinized, and along contacts and shear zones is completely converted to dark-greenish-black serpentine. It encloses lenses and irregular masses of dunite, also partly serpentinized, which in turn enclose the chromite.

The High Plateau chrome deposit appears to have consisted originally of a single continuous tabular body of pure massive chromite, which, however, has been broken by faulting into two or three separate bodies. One of these has been almost completely removed by mining (see plate 5), but it seems to have had a northwesterly strike and a dip of about 11° E., and it is said to have been 8 to 16 feet thick and to have contained about 2,750 long tons of lump ore. It was mined from an open pit. The only trace of it that remains is a thin coating of chromite on what is left of the footwall. The lens that is now being worked was connected to the first by a streak of chromite rubble from 1 to 5 feet thick. The shape of this lens is clearly shown in the profiles in plate 6. It is seen to be a thin tabular body, with minor humps, terminated both to the east and west by faults. It strikes about N. 20° W. and dips 10° to 15° E. It is known to extend 145 feet along the strike and 200 feet down the dip. Its average thickness is about 6½ feet, but a maximum thickness of 16 feet was measured in the area now mined out, and the thickness diminishes toward the north end of the body. The contact of the chromite with the country rock is usually marked by slickensiding and serpentinization, so that almost everywhere the ore breaks freely from both walls. This condition seems to have resulted from the localization of shearing stresses in the contact zone and has nothing to do with the emplacement of the chromite.

The chromite in the deposit is nearly pure and of excellent metallurgical grade: it assays 50 to 55 percent $Cr_2O_3$ and has a chrome-iron ratio of 2.94 to 3.74. Some of the ore is massive and fine grained and contains no gangue except a little serpentine, which is hardly visible, while some is very coarse grained and contains a noticeable amount of carbonate. The latter type, which is found near small faults lined with talc or carbonate, is on the average a little richer in chromium than the finer-grained ore. Along joints and small slips in the chromite the chrome garnet, uvarovite, is commonly found in small well-formed crystals. Associated with the uvarovite is an earthy lilac mineral, which is probably kotschubeite (chrome-bearing clinochlore) but may be kammererite (chrome-bearing penninite).



## GEOLOGIC MAP OF THE
## HIGH PLATEAU MINE
### DEL NORTE COUNTY, CALIFORNIA

CONTOUR INTERVAL 5 FEET
ASSUMED ELEVATION

GEOLOGY BY DELOS E. FLINT
DECEMBER 1942

Perfect octahedra of magnetite, some of them as much as 3 inches in diameter, have been found on the surface below the mine. As none of these have been found in the ore, it is not known whether they are related to the chromite, but they must be related to the peridotite, which is the country rock all around the place where they occur.

There are two large faults in the area, and many small breaks of little importance. Both faults have displaced the chromite blanket several feet. What is believed to be the dominant break in the area bounds the ore body on the east; it strikes north and dips about 80° E. where seen underground, but from evidence seen along the road it is believed that the fault curves or that its displacement is taken up along a fault having the same dip but a more westerly strike (see plate 5). From it extend many small faults that strike east and dip south, some marked by talc seams and some by carbonate veins. The second large fault, which is exposed along the north face of the open cut opened during the first World War, strikes east but dips toward the north. The old cut is in the footwall segment of the ore, which was displaced upward relatively to the hanging-wall segment now being mined. As is common in peridotite, the displacement along this fault was distributed along several planes that branch northwest and southeast from the main fissure. The branch faults dip, like the main fault, at angles of 50° to 80° N. One of them is shown in plate 6. A gouge of talc and chromite rubble from a few inches to 5 feet in width extends along the east-west fault and for short distances along the branching faults.

*Mine Workings.* The High Plateau mine is now being worked entirely from drifts and crosscuts, open-pit mining having become unprofitable before the segment of ore that is now being mined was found. An adit was driven on the 2585 level, just below the stringer which connected the two segments of the ore body, and all mining of the western segment has been carried on from this adit. Three levels have been opened, though the uppermost level is of small extent. Square-setting has been used throughout the mine, and wherever possible the mined-out workings have been backfilled. From the eastern end of the workings on the haulage level an inclined winze was sunk down the dip of the ore, and in 1943 a new adit was driven, 110 feet east of the first adit and 39 feet below it, from which the eastern part of the ore body has been mined. The area mined is shown in plate 6. A vertical ventilating shaft which connects the underground workings with the surface did not cut any chromite.

*Reserves.* In estimating the reserves at the High Plateau mine it has been assumed that there are 9 cubic feet of ore, as measured in place, to a long ton. This figure is based on a specific-gravity determination of 4.18 for a sample of the ore. Careful calculations indicate that the reserves in August 1944 were as follows:

| | |
|---|---|
| Ore blocked out—exposed on 4 sides | 1900 long tons |
| Ore exposed on 3 sides | 1400 long tons |
| Ore indicated by exposure on 2 sides | 650 long tons |
| Total | 3950 long tons |

It would be highly desirable to do some diamond drilling east of the eastern fault, on which the ore body has probably been thrown down. If ore is located by drilling, the drill logs can serve as a basis for planning further underground work. Holes should be drilled along the eastern

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*Reserves.* In estimating the reserves at the High Plateau mine it has been assumed that there are 9 cubic feet of ore, as measured in place, to a long ton. This figure is based on a specific-gravity determination of 4.18 for a sample of the ore. Careful calculations indicate that the reserves in August 1944 were as follows:

| | |
|---|---|
| Ore blocked out—exposed on 4 sides | 1900 long tons |
| Ore exposed on 3 sides | 1400 long tons |
| Ore indicated by exposure on 2 sides | 650 long tons |
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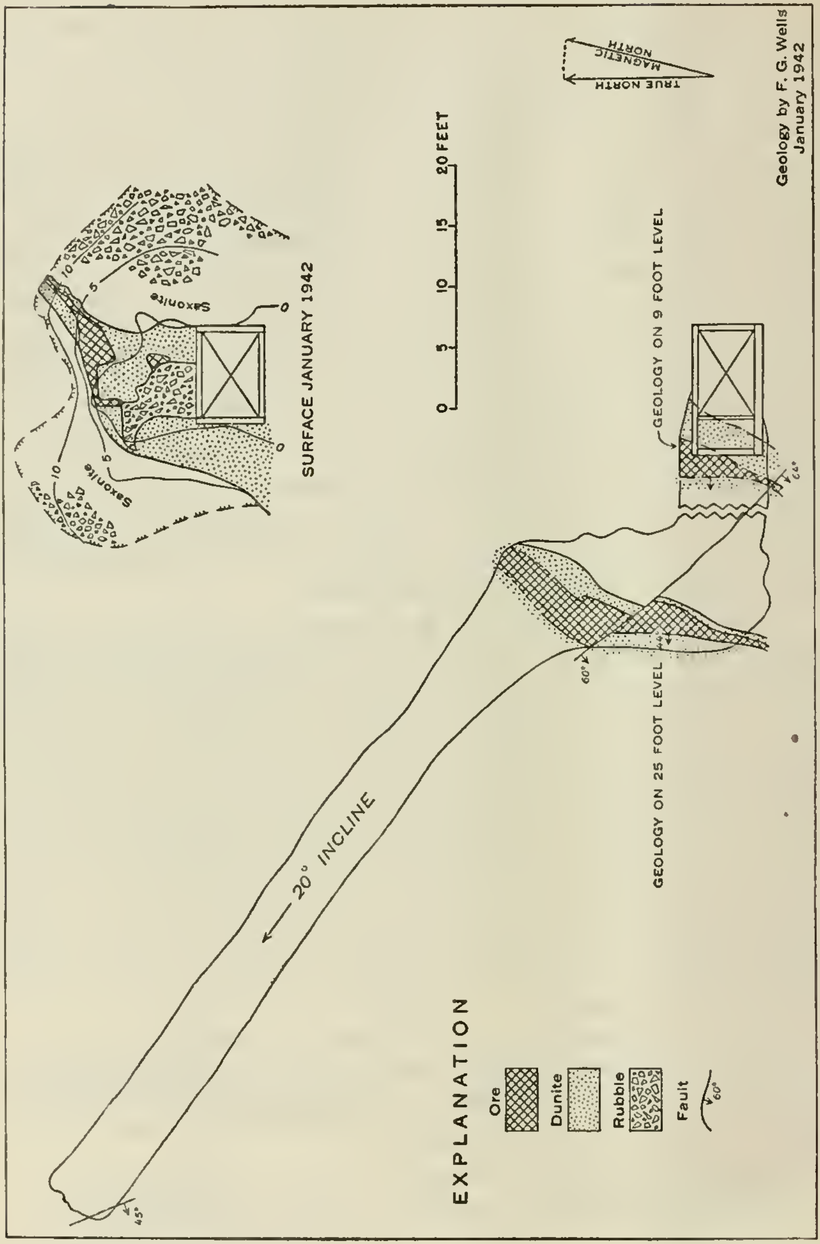

Fig. 3. Geologic sketch map of the workings on the Judy No. 1 claim, Del Norte County, California

side of the fault. If ore is found, additional holes should be drilled on 20-foot centers until the edge of the ore body has been located in a few places, and finally enough holes should be drilled, at places chosen in the light of previous results, to outline the ore in some detail.

*Bench deposits.* Allen [28] describes a bench below the High Plateau mine as follows:

> "Four hundred feet below and 1,000 feet to the S. 25° E. lies a bench, perhaps 150 feet above the creek bottom, with a relatively flat top perhaps 300 feet wide and 300 feet long. The top of this bench is covered with chromite boulders and sand. In some areas the boulders lie so closely spaced that they constitute the only rock appearing. These areas have a tendency to be elongated in a northeasterly direction, suggesting the attitude of the ore bodies above. On the steep slope separating the bench from the deposits below, float is relatively scarce and consists mostly of large boulders (up to 2 feet in diameter) which appear to have rolled from above. Test pits 2 feet square have been dug on the surface of the bench; and while ore is not found as thickly as on the surface, boulders are also present throughout the soil.
>
> "Considering the position of the bench, the steepness of the slope from the north, and the distribution of the ore on the bench and slope, it is logical to assume that the bench is essentially a landslide block which rode down hill on an even keel and much in one piece, retaining the level surfaces which characterizes the surface of the ridge above."

In the winter of 1943-44, 90 long tons of chromite was picked up on this bench and sold to the Metals Reserve as coming from the Long Hike or Dipper claim. If this bench were sluiced during the rainy season, much chromite float could be recovered, and the rock laid bare could be examined, also, for any evidence of ore below the surface.

### Bonanza (12)

Late in 1941 Clarence Strong, Delbert O'Brien, and Clifford Johnson found some chromite just over the ridge from the High Plateau mine and 1800 feet to the northeast of it. They filed on this discovery as the Bonanza claim and during 1942 they produced 137 long tons of ore, which on the average carried 50.5 percent $Cr_2O_3$ and had a Cr/Fe ratio of 2.82. The mine is in sec. 21, T. 18 N., R. 2 E., and is reached by a poor dirt road a mile long extending westward from the High Plateau forest road. It is on the upland surface, at an altitude of 2875 feet (see pl. 4).

In November 1942 the workings consisted of an inclined shaft 50 feet deep with a stope on the east side, and a pit lying south of the shaft and just below the road.

The country rock in the prospect is peridotite, intensely sheared and serpentinized along a shear zone at least 6 feet wide, striking N. 30° E. and dipping 30° NW. The peridotite in the shear zone is altered to serpentine and talc—the latter being locally so abundant as to make the rock a soapstone or steatite—and it is characterized by color banding in irregular concentric shells. Lumps, bunches, and stringers of ore are scattered through the shear zone. Most of the individual ore bodies contain less than 100 pounds, though some bunches containing several tons have been found. No ore was in sight when the mine was examined. A little disseminated ore can be seen in small outcrops of serpentinized but unsheared dunite a few hundred feet southwest of the incline.

### Judy Mine (11)

The Judy mine is in sec. 29, T. 18 N., R. 2 E., a mile and a half west of the High Plateau mine and at about the same altitude of 2600 feet (see pl. 4). It is reached by 3½ miles of poor dirt road, not passable for passenger cars except in the best of weather, branching from the High Plateau road. Low Plateau is here a narrow spur of rolling upland, not over 1000 feet wide. On the north it breaks off abruptly, a precipitous slope descending from its brow for 1800 feet to the North Fork of Smith River; on the south it slopes steeply to Peridotite Canyon, 1000 feet below. Murphy Hicks of Cave City, Oregon, discovered chromite here in the winter of 1941-42 and filed on three claims, the Judy No. 1, Judy No. 3, and Judy No. 4. Late in 1942 he leased the property to the Crescent Pacific Mining Company, which operated the mine until some time in 1943, taking out 373 long tons of ore.

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[28] Allen, J. E., op. cit., p. 117.

Early in July 1942, when the property was first visited by members of the Geological Survey, exposures were good and several thousand square feet had been scraped clean with a bulldozer. The country rock was seen to be rather fresh saxonite enclosing irregular, generally small bodies of dunite. No zones of intense shearing were observed. Several widely scattered small bunches of coarse-grained chromite, frozen to the rock, were found on the west wall and floor of a pit about 10 feet square and 5 feet deep (see fig. 3). Underground development showed that this chromite was part of an ore body that can be likened to a steeply plunging sausage, irregularly squeezed and flattened. At a depth of 25 feet the ore body was lenticular in horizontal cross-section, trended slightly east of north, and dipped 45° W. It is enclosed in an irregular body of dunite having about the same general attitude.

The hanging wall of the ore is marked by a distinct slip, along which the dunite has been altered to clay. The footwall also is marked by slippage and alteration, and at one place it is covered by a small body of talc. The ore breaks freely and cleanly from the country rock, but because of many joints and clayey seams it was difficult to keep the hangingwall rock from falling in and diluting the ore. At a depth of 25 feet the ore is cut by a fault that strikes N. 45° W. and dips 64° SW., on which the southwest block has moved a foot or so to the southeast. On the north side of the fault the ore was followed down the dip for another 53 feet, but at that depth it wedged out.

The ore is massive and consists of grains of various sizes, the largest about an eighth of an inch in diameter. The ore shipped contained from 42.68 to 45.20 percent $Cr_2O_3$ and 10.43 to 10.97 percent Fe, and had a Cr/Fe ratio of 2.74 to 2.92.

### Bluebird Prospect (10)

The Bluebird prospect was located and opened up in 1943 by J. E. Eckett, H. G. Miller, and E. G. Tarbell, of Cave City, Oregon, who filed on three claims, the Bluebird No. 1, No. 2, and No. 3, in sec. 29, T. 18 N., R. 2 E. The workings lie about a third of a mile south of the Judy mine, at an altitude of 1700 feet, on the north slope of Peridotite Canyon (see pl. 4). The nearest water is in the small creek in that canyon, 1500 feet lower than the mine. The prospect is reached from the High Plateau road by 3½ miles of dirt road passable for automobiles in dry weather, and three-quarters of a mile of steep tractor trail.

These lenses of chromite are prospected by three pits. All three of these lenses are in landslides and are considerably broken. The ore in all of them consists partly of solid chromite and partly of high-grade disseminated chromite in a matrix of talc and serpentinized dunite. The dominant country rock is partially serpentinized saxonite, but each of the chromite bodies appears to be envoloped by a thin shell of dunite. Up to August 1, 1944, shipments from this property had amounted to 75 long tons. The assays of the shipment ranged between the following limits: $Cr_2O_3$ 41.83-45.73 percent, Fe 10.57-11.21 percent, Cr/Fe ratio 2.552-2.959.

### Skyline Mine (9)

The Skyline mine lies nine-tenths of a mile southwest of the Judy mine and three-fourths of a mile west-southwest from the Bluebird mine, on the narrow ridge between Peridotite Canyon and a short tributary of Smith River (see pl. 4). The mine can be reached from the High Plateau road by way of a 3½-mile dirt road, passable in dry weather, and one mile of trail. This claim was discovered in July 1944, by J. E. Eckett and H. G. Miller, and is now owned by them and their partners E. G. Tarbell and J. C. Rodgers.

Exposures on the claim are very good, especially along the steep west side of the ridge. The chromite is in the central part of a lens of dunite 200 feet long. This lens is sinuous, striking N. 45° W. to N. 60° E., and dips at a moderate angle into the hill (see fig. 4). Other irregular bodies of dunite are scattered through the saxonite in the vicinity of the mine, but none appear to contain an appreciable quantity of chromite. In the saddle, 60 feet below, the chromite is highly sheared.

The chromite ore is in part massive and in part disseminated; it contains a little uvarovite. The ore in sight has slipped down the hill a few feet, so that the exact relations of the various type of ore to each other and of the ore to the dunite are not certain. Some of the individual blocks of ore lie transverse to the dunite lens, but that may be a result of sliding. The ore zone is about 80 feet long and up to 6 feet thick. The massive ore consists of close-packed imperfect crystals of chromite 3 to 6 millimeters in diameter; the disseminated ore consists of irregular grains of chromite of about the same size, in a matrix of dunite. There is only a thin shell of dunite at the sides of the ore deposit, but along the strike at the ends of the deposit the nearly barren dunite has a width of about 10 feet. The contacts of the ore with barren dunite seem to be relatively sharp, although they are not sheared.

When the property was visited about 25 tons had been mined and lay on the dumps, and perhaps 50 tons more were in sight. The property may contain about 300 tons of "indicated" ore and 700 tons of "inferred" ore. The ore shipped has carried from 44.35 to 50.55 percent $Cr_2O_3$ and 9.54 to 10.79 percent Fe, and has had a Cr/Fe ratio of 2.73 to 3.52. Shipments to October 31, 1944, were 165 long tons.

## Upper Diamond Creek Area

The Upper Diamond Creek area comprises 10 square miles in the drainage of Diamond Creek, above its confluence with High Plateau Creek (see pl. 1). It lies within T. 18 N., R. 2 E., and is 13 miles from O'Brien by way of the Wimer road, which traverses the northern part of the area. Patches of metavolcanic rocks and of various kinds of intrusive rock crop out in this area, so that the bottom of the peridotite may not be very far below the surface. Several zones of slickentite cross the area, and evidences of landsliding are common. The only chromite deposit that has been worked is just over the divide from the Patricks Creek area.

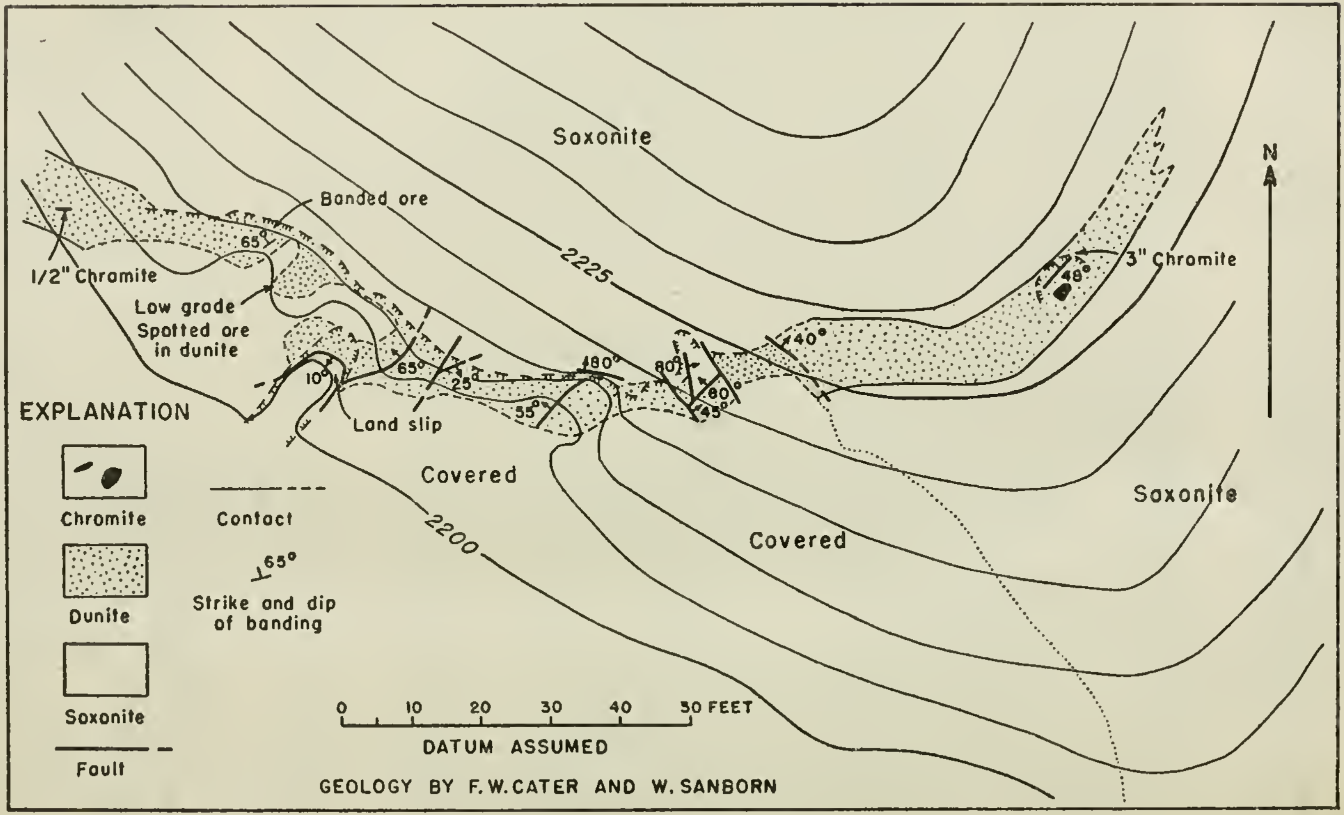

FIG. 4. Sketch map of the Skyline mine, Del Norte County, California

Several croppings of chromite have been seen along the west side of the valley of the North Fork of Diamond Creek, in sec. 1, T. 18 N., R. 2 E. The peridotite here projects partway up into the ridge, but tongues of intrusive rocks lie within a few thousand feet to the east and west. No work has been done in this vicinity.

### Richey Property (14)

The Richey property is in sec. 5, T. 18 N., R. 3 E., a mile south of Diamond Creek and about a mile and a half south of the point where the Wimer road crosses the Oregon State line, at an altitude of 2650 feet (see pl. 1). Some prospecting was done in this area during the first World War. In 1943 the brothers S. J. and V. I. Richey prospected and mined one of the masses of float in the area. They shipped over 13 long tons of ore, which assayed 39.5 percent $Cr_2O_3$ and had a Cr/Fe ratio of 2.42.

When the mine was visited in September 1944, an upper deposit had been developed by an open cut 15 feet long, 15 feet wide, and 10 feet deep. A lower deposit had been mined from a glory hole 20 feet long, 10 feet wide, and 8 feet deep, and an adit driven S. 70° W. from a point 40 feet farther down the slope and 20 feet lower. Another adit having the same trend had been driven at a lower level. Both adits were caved.

The attitude, size, and shape of the ore bodies are not known, but from the trend of the workings it seems likely that the lower deposit had a northwesterly strike and a steep dip. This may be the deposit mined by S. J. Richey, who described it as a nearly vertical stringer 3 to 4 inches wide, with one side frozen to the wall rock and the other side breaking cleanly. He followed this stringer for more than 20 feet.

The deposits lie well within the peridotite, being about a third of a mile west of the contact. The principal country rock around both deposits is partially serpentinized saxonite, but some dunite was seen at the lower workings. Most specimens of ore from the lower deposit consist of disseminated grains, irregular streaks, and clots of chromite in a matrix of serpentinized dunite. The individual grains of chromite are from 0.1 to 5 millimeters in diameter. Some pieces of massive chromite also were seen. The reserves cannot be estimated but appear to be small.

### Logan Claim (16)

What is commonly called the Logan claim was staked in the spring of 1942, by Richard Noue and James Curnow. George Logan leased the claim from them, and shipped about 9 long tons of ore to the Metals Reserve stockpile at Grants Pass in 1943.

The claim was not visited, but it is described as being at the head of the South Branch of Diamond Creek, at an altitude of 3100 feet, in sec. 17, T. 18 N., R. 3 E. It is a mile east of the Toujours Gai claim, less than half a mile north of the High Dome claim, and about the same distance west of the peridotite contact. The ore forms a narrow tabular body dipping into the hill. An adit has been driven on it, but the work was discontinued because of the hardness of the rock.

## Patricks Creek Area

The Patricks Creek area lies at the head of that stream and near the eastern contact of the Josephine peridotite massif. Along this contact, which dips steeply eastward, the peridotite is strongly sheared and is

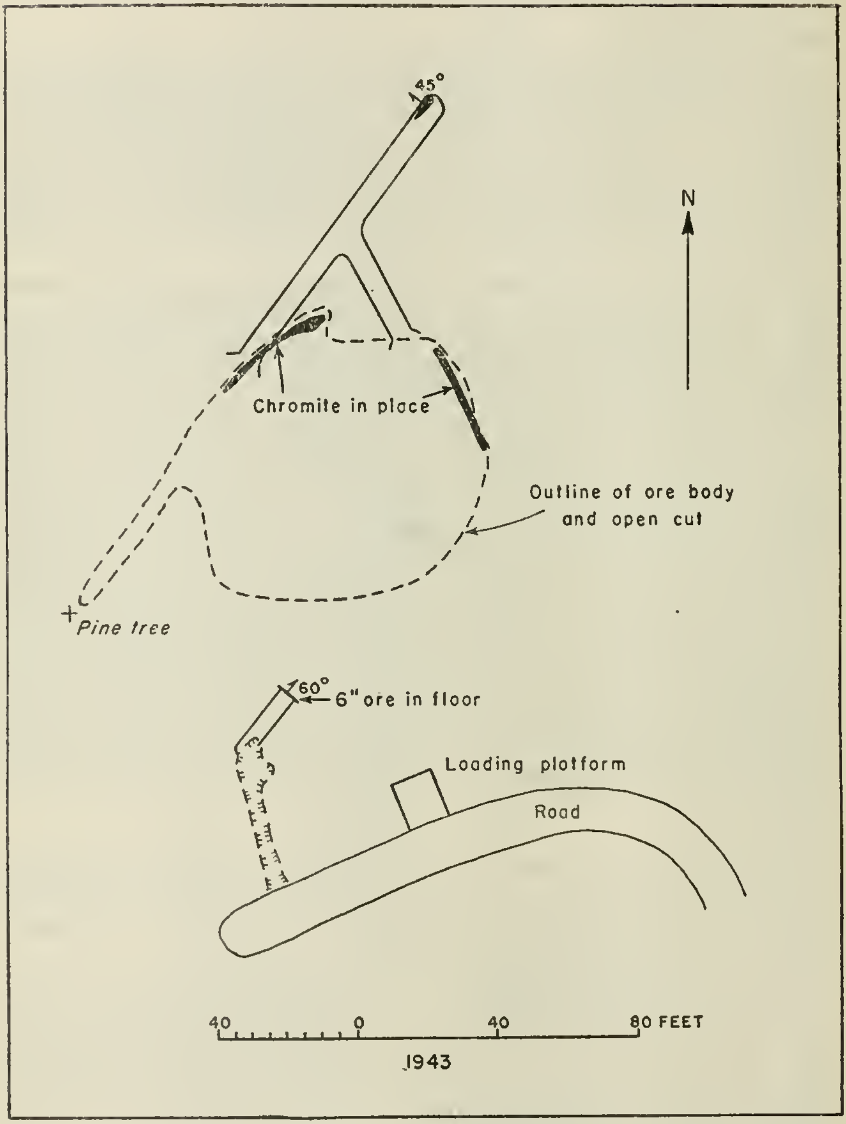

FIG. 5. Sketch map of the Toujours Gai chromite mine, Del Norte County, California

thoroughly serpentized over a width of several hundred yards, but west of the shear zone the rock is only partially serpentized. All the chromite deposits found so far are several hundred feet west of the contact. The area is reached by way of the Forest Service road up Patricks Creek, which follows the bed of the creek for 4 miles and then climbs for a distance of 5 miles up the west side of the valley to the ridge top. This road is impassable to motor vehicles during wet weather. It joins Highway 199 sixty-two miles from Grants Pass.

### Toujours Gai Claim (17)

The Toujours Gai claim is in the NW¼ sec. 19. T. 18 N., R. 3 E., on the brow of Elk Camp ridge. It lies west of Patricks Creek, at an elevation of about 3200 feet (see pl. 1). The discovery was made in 1942 by David Webb, who, together with H. T. Borgman and W. T. Stilwell located the claim and leased it in the winter of 1942-43 to Harry Messenger.

When the deposit was discovered the outcrop showed only a streak of chromite a fraction of an inch wide and a few inches long, but by September 1943 a blanket of massive chromite extending over a rectangular area 75 feet long and 70 feet wide had been exposed (see fig. 5). The blanket has an undulatory surface, is 6 inches to 3 feet thick, pinches out northwestward, and apparently dips in that direction. It is irregularly displaced by many small faults with throws of less than a foot. The ore is enclosed in dunite, which has been completely altered to serpentine and somewhat sheared. In places the ore, which is massive and coarse grained, is frozen to the dunite, and in places it breaks free. Production to the end of 1943 was 264 long tons of ore, which contained 45 to 51.5 percent $Cr_2O_3$ and 10.7 to 11.3 percent Fe and had a Cr/Fe ratio of 2.52 to 3.20.

### Tangerine Claim (15)

The exposures on Elk Camp ridge are good; the outcrops are mostly of saxonite, but irregular small patches of dunite are found. Many of the dunite patches enclose wisps of chromite, and lumps of chromite a fraction of an inch in diameter. Some digging has been done, but none of the deposits thus far uncovered appears to contain more than a few tons of ore. A deposit lying northwest of the Toujours Gai claim, in the NW¼ sec. 18, T. 18 N., R. 3 E., is in the Tangerine claim (15), located by David Webb, H. E. Borgman, and W. T. Stilwell.

### High Dome Claim (19)

The High Dome claim is at the head of the West Fork of Patricks Creek, in the NW¼ sec. 20, T. 18 N., R. 3 E., at an altitude of 2550 feet. The property was located by Edward Cook, who leased it to J. K. Remsen and C. H. Bennett in 1942. It is accessible from Highway 199 by way of 7 miles of dirt road. Its workings include a caved adit and an open cut, which is 120 feet long and 10 feet deep in the face.

The claim is in peridotite, about half a mile west of the eastern contact. The principal country rock is serpentinized saxonite; much of it is cut by light-green veins of serpentine, and a zone of sheared serpentine is exposed in the west end of the open cut. A small amount of serpentinized dunite was found on the dump, but none was seen in place. The ore is said to have formed a lens from 1 to 4 feet thick, but its attitude is not known, for no ore was seen in place. The ore that remained on the

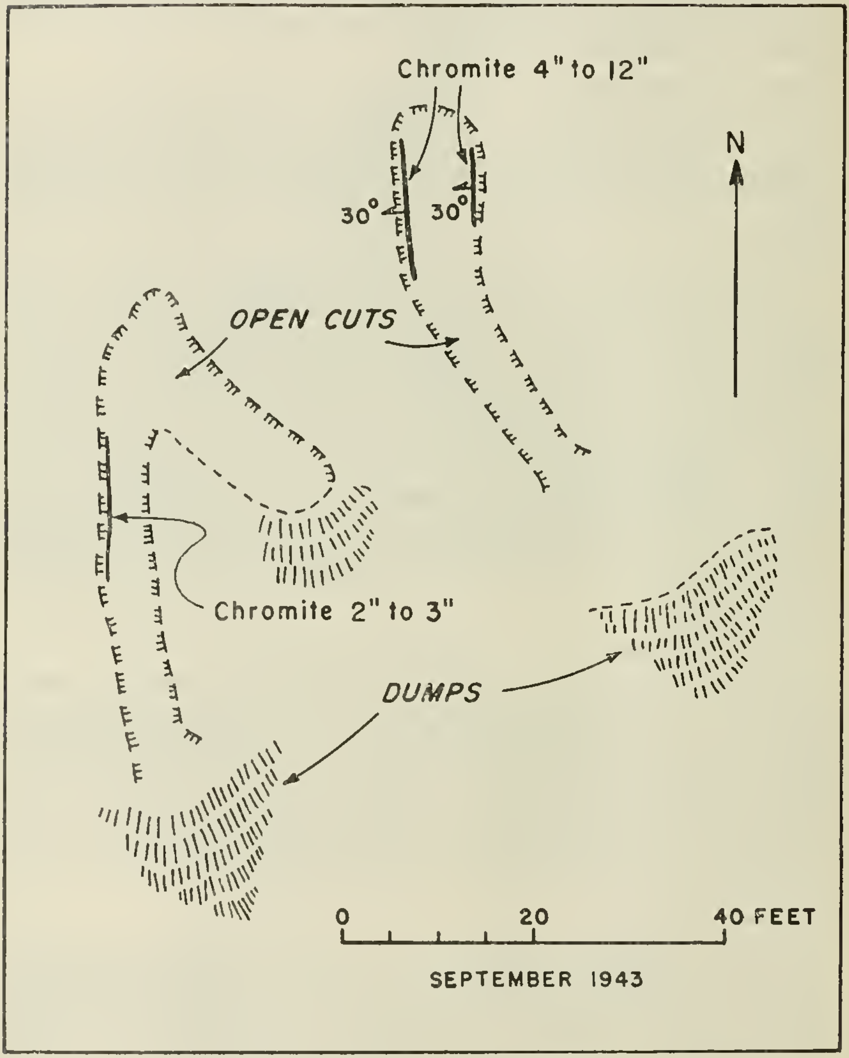

FIG. 6. Sketch map of Chrome Hill No. 1 claim, Del Norte County, California, September 1943

dump was partly high-grade medium-grained massive chromite, and partly low-grade spotted ore consisting of irregular grains of chromite about a tenth of an inch in diameter enclosed in a matrix of serpentinized dunite.

The mine produced 126 long tons of ore, containing 44.6 percent $Cr_2O_3$ and having a Cr/Fe ratio of 2.48. According to the operators the deposit was mined out.

### Chrome Hill No. 1 Claim (18)

The Chrome Hill No. 1 claim is in sec. 30, T. 18 N., R. 3 E., a mile south of the High Dome mine, on the west side of Patricks Creek gulch, at an altitude of 2460 feet (see fig. 6). A truck trail seven-tenths of a mile long connects the workings with the Patricks Creek road, which it joins 8 miles north of Highway 199.

The topography immediately southeast of this deposit and on the slope below the mine indicates landsliding on a large scale, but little evidence of landsliding was noted at the prospect. The deposit lies about a mile west of the eastern contact of the peridotite, which is here partially serpentinized but, so far as could be judged from scattered outcrops, not greatly sheared. The chromite occurs in stringers, which strike N. 15° E. and dip about 30° W. They have been explored by two trenches (see fig. 6). In the eastern trench the soil cover is thick and rests on a layer of broken peridotite that slopes westward—a possible indication of landsliding. In this trench two stringers of chromite can be seen, separated by about 4 feet of rock. The ore is frozen to the dunite and is between 1 foot and 6 inches in average thickness. In the western trench there is a discontinuous, weathered, friable stringer that dips less than 30° W. Production to the end of 1943 was 20 long tons, which assayed 45.9 percent $Cr_2O_3$ and 11.34 percent Fe and had a Cr/Fe ratio of 2.77. This claim does not seem promising.

## Gasquet Area

The Gasquet area, which includes Gasquet Mountain and the lower end of Elk Ridge, comprises about 9 square miles north of the Middle Fork of Smith River. It is bounded on the west by the contact of peridotite with metavolcanic rocks. A truck trail giving access to some of the claims leaves Highway 199 near Gasquet, which is 70 miles from Grants Pass. Three claims in this area, the Niggerhead (25), Angela (23), and Blackjack (24), were mined during the first World War.

### Niggerhead Claim (25)

The Niggerhead claim is about a mile north of Gasquet, between the lower and upper switchback on the Low Divide trail, in the SW¼ sec. 17, T. 17 N., R. 2 E. The upper part of the deposit is about 2 miles east of the contact, at an altitude of about 1350 feet. When it was visited in May 1944, little could be seen. Allen [29] describes the conditions on this claim as follows:

> "The workings lie about 600 feet above the trail, and are connected by a string of small float extending for at least 300 feet N. 20° W. in a sheared talcose zone from 10 to 30 feet wide. The country rock is dark-green to black serpentine, with much light-colored pyroxene in stringers. The surface weathers to bluish gray.
>
> "Several small open cuts expose ore along this zone. The chromite in place was in small bodies and the grade was medium. About one ton of 40-50 percent chromic

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[29] Allen, J. E., op. cit., pp. 118-119.

oxide content ore has been mined at the southern cut. The body is here from 10 inches to 2 feet thick, and not very extensive.

"Large water-worn float boulders of chromite lie on the ridge top 30 feet above to the west and also to the north, and a string of float also leads down to the creek bed 50 feet below. In the east wall of the creek 200 feet upstream and 10 feet above the water, a kidney measuring 4 by 4 feet lies in a serpentine breccia.

"Another large cut lies due east of the first one, near the bottom of the second gulch. About 6 tons of medium-grade ore are piled by this cut, and no ore is to be seen in place. The ore is crusted and cut by serpentine stringers and has to be carefully cobbed and sorted."

### Blackjack Chromite Claim (24)

The Blackjack chromite claim, owned by George Wisston of Gasquet, is in the NW¼SW¼ sec. 17, T. 17 N., R. 2 E., about half a mile north of Gasquet, at an altitude of 1280 feet. It lies about 3000 feet northeast of the Niggerhead claim and is accessible from Gasquet by way of a poor truck trail.

The chromite body was contained in a zone of sheared serpentine, in which one can recognize small pieces of unsheared but serpentinized saxonite. The shape and attitude of the ore body are unknown, and no ore remains in sight. On the dump there are fragments of massive, medium-grained chromite containing a little kammererite. The only accessible opening is a small bulldozer cut, which has obliterated the workings from which the ore was taken during the first World War.

About half of the ore shipped from this area in 1942 came from the Blackjack claim.

### Angela Chromite Mine (23)

The Angela chromite mine, like the Blackjack, is owned by George Wisston. It lies 1800 feet north-northwest of the Blackjack, at an altitude of 1510 feet, and is accessible from Gasquet by 2 miles of truck trail.

The deposit consisted of two or three small pods of chromite contained in somewhat sheared, serpentinized saxonite and dunite. A little dunite is still visible in the sides of the cut, and the chromite appears to have been surrounded by dunite. No ore was seen in place, but on the dumps there are pieces of high-grade medium-grained chromite containing a little uvarovite and kammererite. The serpentinized peridotites are cut by narrow seams of light-green serpentine and chrysotile. The workings consist of four small open cuts extending along a N. 40° W. line for 150 feet. These cuts are badly caved and little could be seen in them.

## French Hill Area

### General Features

The French Hill area comprises about 2 square miles on the western end of French Hill, a narrow flat-topped ridge on the south side of the valley of the Middle Fork of Smith River, in T. 17 N., R. 2 E. A steep gravel road 2 miles long leads to the top of the ridge from a point on Highway 199 seventy miles southwest of Grants Pass (see pl. 1).

The French Hill deposits are in a tongue of peridotite projecting southward from the Josephine mass. At its northern end, where it is crossed by the highway, this tongue is about a mile wide, but a mile and a half to the south its western boundary swings abruptly to the east, reducing the width to about 1000 feet. The narrow portion of the tongue continues southward for another mile and a half. Heavy brush obscures

*A*. TOUJOURS GAI MINE, DEL NORTE COUNTY

Face of ore at lower part of bank at left, and in drift

*Photo by Walter W. Bradley, September 1943*

*B*. TOUJOURS GAI MINE, DEL NORTE COUNTY

Note shallowness of overburden on flat-lying orebody. Chromite dips into bank at left. Extracted ore in foreground

*Photo by Walter W. Bradley, September 1943*

the geology throughout the area, and on the top of the ridge the distribution and structure of the peridotite are further concealed by a mantle of Tertiary sand and gravel (see pl. 8). The peridotite is flanked by metavolcanic rocks believed to be of upper Jurassic age. As pointed out in the chapter on structure, the peridotite is believed to form the crest of the south-plunging anticline, and the remnants of metavolcanic rocks at the French Hill mine have an anticlinal structure (see pl. 9). The peridotite is mostly saxonite, not highly altered in general but serpentinized and sheared, so as to form slickentite, at the French Hill mine and at some places along the eastern contact. Three chromite deposits have been mined in the area, one on the Fairview claim (27), one on the Margy claim (26), and one at the French Hill chromite mine (28), all of which are owned by Tyson Chrome Mines, Ltd.

### Margy and Fairview Claims (26 and 27)

The Margy and Fairview claims have been described by Allen[30]. As no work has been done on them during the present war they were not visited by the Geological Survey party.

### French Hill Chromite Mine (28)

*Location, History and Production.* The French Hill chromite mine is in the NE¼ sec. 6, T. 16 N., R. 2 E., at an altitude of about 1550 feet (see pl. 8). It is connected with U. S. Highway 199 by 6 miles of graded Forest Service road. The property consists of the French Hill claim, patented in 1886 as Mineral Lot No. 37, and the Chrome Ridge Nos. 1, 2, 3, and 4 claims, located in 1941. All the claims are owned by the Tyson Chrome Mines, Ltd., of 406 Montgomery Street, San Francisco, California.

About 400 long tons of ore was mined by the Tyson Mining Company in the 1880's, but apparently none was shipped. The American Exploration and Construction Company operated the property during 1917 and 1918 under a lease from the Tyson Estate of Baltimore, Maryland. The property then lay idle until 1941, when C. H. McClendon reopened the east ore zone under a lease from Letticia B. Nimick, of Bay Head, New Jersey, who had acquired the title from the Tyson Estate. In 1942 the present owners took over the property and have operated it ever since. All mining had been done on the east ore zone until, in 1942, the west ore body was accidentally uncovered while ground was being cleared with a bulldozer.

*Geology.* Logan[31] and Maxson[32] have briefly described the property.

Wells first examined the mine in 1940. Gros mapped the deposit in 1942, and it was remapped by Rynearson, Cater, Dow, and Williams in 1943, at which time a report containing recommendations as to development was prepared by Rynearson. The U. S. Bureau of Mines diamond drilled the deposit in the months April to July 1944. Cater

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[30] Allen, J. E., op. cit., p. 118.

[31] Logan, C. A., *in* Bradley, W. W., and others, Manganese and chromium in California: California Min. Bur. Bull. 76, pp. 127-128, 1918.

[32] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwesternmost California: California Jour. Mines and Geology, vol. 29, pp. 154-155, 1933.

*Production of chromite from the French Hill mine*

| Year | Ore shipped (long tons) | Percent $Cr_2O_3$ |
|---|---|---|
| 1917[1] | 2773 | 40 |
| 1918[1] | 1267 | ? |
| 1919-1940 | none | — |
| 1941 | 495 | 44 |
| 1942 | 1438 | 44 |
| 1943 | 8030 | 44 |

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[1] Figures for 1917 and 1918 are from unpublished records of the Bureau of Mines.

applied his geologic knowledge in guiding this work, and also remapped the deposits with the cooperation of William Sanborn of the Bureau of Mines.

As already stated, the French Hill mine is in peridotite at the crest of what is believed to be a narrow anticline. Although the peridotite is largely altered to serpentine, its original character can still be recognized in many places. It is chiefly saxonite, which, however, encloses irregular layers of dunite lying parallel to the contacts with the older rocks. The largest body of dunite exposed by mining and drilling is not more than 260 feet long, 175 feet deep and 100 feet thick. Where the combined thickness of dunite and chromite is greatest, the dunite is thin, and in places it is little more than a rind on the ore (see pl. 9). The dunite in contact with the pods of chromite is highly sheared slickentite, made up of boulders of recognizable dunite. A short distance beyond the ore bodies the slickentite merges into relatively unsheared serpentine.

The chromite is generally flanked by a layer of hard, fine-grained, white rock, in places as much as 3 feet thick, which locally penetrates the ore in tongues that resemble short dikelets. This white rock, which is called rodingite, consists mainly of diopside, wollastonite, and garnet. In other localities[33] rodingite is closely associated with diorite dikes, but no diorite dikes were seen in the French Hill area.

The area mapped contains three masses of the partly metamorphosed fragmental volcanic rocks into which the peridotite was intruded. These are believed to be part of the Galice (?) formation, of upper Jurassic age. The contacts of the two larger masses with the peridotite are highly sheared and are shown on the map as faults. The eastern fault is roughly parallel to both the bedding in the volcanic rocks and the layering in the peridotite, which strike N. 20°-70° E. and dip 25°-70° SE. The western fault cuts across the bedding in the metamorphosed sedimentary rocks but lies roughly parallel to the layering in the peridotite. The third mass is poorly exposed and the nature of its contact is uncertain, but that contact also is probably a fault. Faulting is not evident within the volcanic and sedimentary rocks; marked fracturing and shearing are confined to the peridotite at the contacts and around the massive chromite. No evidence was found that these volcanic rocks were altered by the peridotite.

*General Features of the Ore Deposits.* Irregular pods and lens-shaped bodies of high-grade ore coated with sheared peridotite occur near the eastern and western borders of the intrusive mass. Some of the ore is almost pure chromite, but most of it contains some interstitial serpentine, talc, or magnesite. In parts of the ore bodies that have been fractured and sheared, fracture surfaces are commonly separated by a gouge of serpentine or coated with a thin skin of serpentine. Ore adjacent to the light-colored rodingite is commonly shattered and mixed with the same minerals that make up the rodingite. Some of the ore, especially along fractures and near the rodingite, contains a little kammererite and uvarovite, and crevices in the ore are lined with delicate needles of magnesite and what appears to be aragonite.

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[33] Rynearson, G. A., and Wells, F. G., Geology of the Grey Eagle and other chromite deposits in Glenn County, California: U. S. Geol. Survey, Bull. 945-A, p. 7, 1944.

Most of the ore consists of more or less well formed crystals of chromite ranging from 1 millimeter to 1 centimeter in diameter, the variations in texture being largely due to variation in the quantity of gangue. A small ore body at the northeast edge of the area mapped consists of ill-formed nodules of chromite, and some of the ore in the east workings consists of irregular, somewhat elongated clusters of chromite crystals in a matrix of talc, kammererite, and magnesite. Most of the chromite is iron-black and has a sub-metallic lustre, but that in some parts of the western ore bodies is brownish black and has a vitreous luster. Some of the ore in both the western and eastern ore bodies has been granulated by shearing stresses and now has a dense, fine-grained texture, a chocolate-brown color, and a dull lustre.

Almost everywhere the ore breaks cleanly from the adjacent serpentine, and in many places it has highly polished surfaces on the contacts, but some specimens taken on dumps have gradational contacts. In the few places where the contact of the ore and barren serpentine is not sheared, there is a transition zone a few inches thick in which layers containing abundant disseminated chromite alternate with layers of barren serpentine.

A composite grab sample was collected from the ore bin in July 1942. The ore of which it consists probably came from the upper ore body of the west ore zone. An analysis of this sample has been given in table 1.

According to the operators the ore mined up to the end of 1943 averaged 44.87 percent $Cr_2O_3$, 12.13 percent Fe, and had a Cr/Fe ratio of 2.53. Most of the shipments have varied but little from these averages; for the most part it has contained from 40 to 47 percent $Cr_2O_3$, and from 11.38 to 13.86 percent Fe. The sample analyzed by Carron appears to have been unusually high in iron. The ore that was being mined about August 1, 1944, from the western end of the middle ore body likewise had a high iron content (13.63 Fe). One carload lot assayed only 38.41 percent $Cr_2O_3$ and contained 13.13 percent Fe, making a Cr/Fe ratio of 2.00.

*East Ore Zone.* The first ore discovered was in the east ore zone, which is in a tabular body of highly sheared and serpentinized dunite lying on the east limb of the anticline. The base of the zone lies parallel to and about 50 feet west of the contact of the dunite with the volcanic and sedimentary rocks. It strikes N. 20°-50° E. and dips 30°-50° SE. A few quarter-inch seams of disseminated chromite occur in this zone. According to Caldwell,[34] who visited the property in June 1918, a series of chromite pods was strung along this zone for a distance of 100 feet. They were from 1 to 15 feet thick, and were elongated in the direction of dip (see pls. 9 and 10). Ore has been mined for a distance of 120 feet down the dip, and has been intersected by drill holes 50 feet lower. Whether any one pod was continuous to such a depth as 170 feet before the faulting occurred is uncertain.

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[34] Caldwell, F. B., Unpublished report U. S. Bureau of Mines, 1918.

Most of the ore known to have been present originally in this zone has already been mined from an open cut and two levels of underground workings. No ore remains in the open cut, but some is left in pillars in the underground workings, and ore from a foot to a foot and a half thick may be seen in the walls of the winze on the lowest level. The ore exposed in the underground workings is cut off by a fault along its northwestern or upper edge. The ore mined from the surface, and probably that mined underground, once formed a single continuous body which has been cut in two by this fault.

In 1941-42 the northwestern underground workings had been caved and filled and had not been reopened. Three diamond-drill holes (No. 11, 99 feet long; No. 12, 95 feet long; and No. 13, 120 feet long) have been put down to test this block of ground. They were so pointed as to intersect the ore 40 feet down the dip, and where they penetrated the shear zone there was about 2 inches of ore. They indicate that the ore body extends down at least 40 feet beyond the present workings but is too thin to be worth mining. Apparently the present surface beveled the ore body near the level at which it was thickest. If there are any other ore bodies in this zone, they probably lie so far from the surface that wildcatting for them is not justified with chromite at its present price. Production from this zone has been 4,585 long tons.

*West Ore Zone.* The west ore zone, on the west limb of the anticline, is about 200 feet west of the east ore zone and at an altitude of 1620 feet (see pl. 11). It is a rudely tabular body of thoroughly sheared serpentinized dunite enclosing pods of massive chromite. The upper surface of the zone, which lies parallel to the contact with the overlying volcanic rocks and 40 feet below them, strikes about N. 15° E.. dips about 15° W., and plunges to the southwest. As the zone bellies and pinches, its thickness varying from 10 to as much as 100 feet, the lower surface is quite irregular (see pl. 11). The ore body has a maximum extent of 175 feet down the dip and 260 feet down the plunge.

Six large and several smaller partially overlapping and closely spaced pods occur in this zone. The large pods are numbered 1 to 6, from east to west, for purposes of description. They are of irregular shape, but the longest axes of all of them extend down the dip of the ore zone.

Ore body No. 1 has been almost completely mined out through an open cut and a short drift and stope. Some ore still remains in the face of the cut, and a little probably remains in the floors of the cut and drift. So much of the ore has been extracted that the size and shape of the ore body cannot be known in detail, but they are shown approximately in plate 11. It is estimated that this body was, at a maximum, 60 feet long on the dip, 35 feet wide on the strike, and 15 feet thick. The average thickness was about 7.5 feet. Numerous partings of serpentine occur within the limits of the ore body, and only about two-thirds of it, by volume, appears to have been mined and shipped as ore.

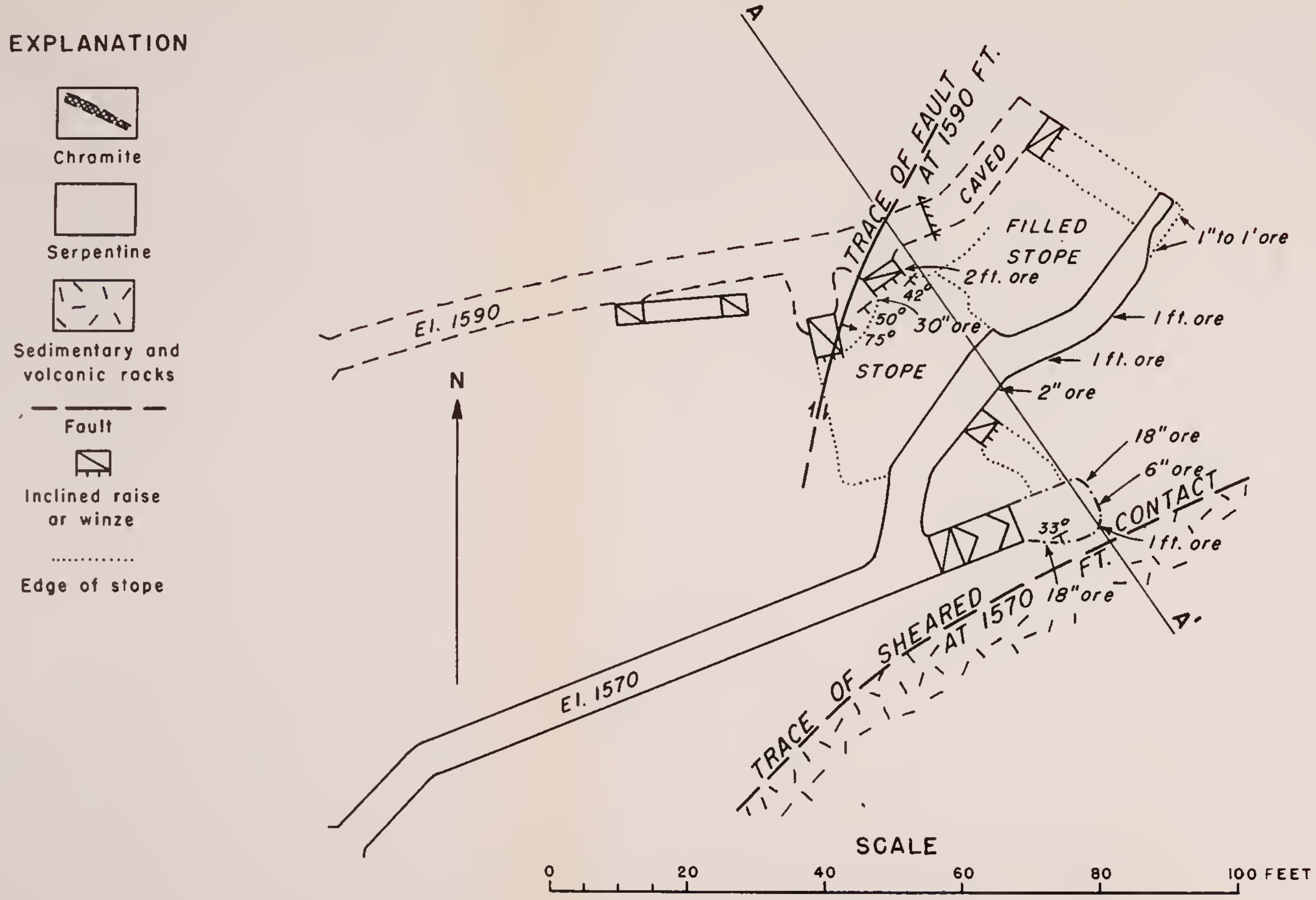
Ore body No. 2 lies a few feet westward from the No. 1 ore body and a little farther down the dip. It had a maximum thickness of about

DIVISION OF MINES
W. BURLING TUCKER, STATE MINERALOGIST
OLAF P. JENKINS, CHIEF GEOLOGIST

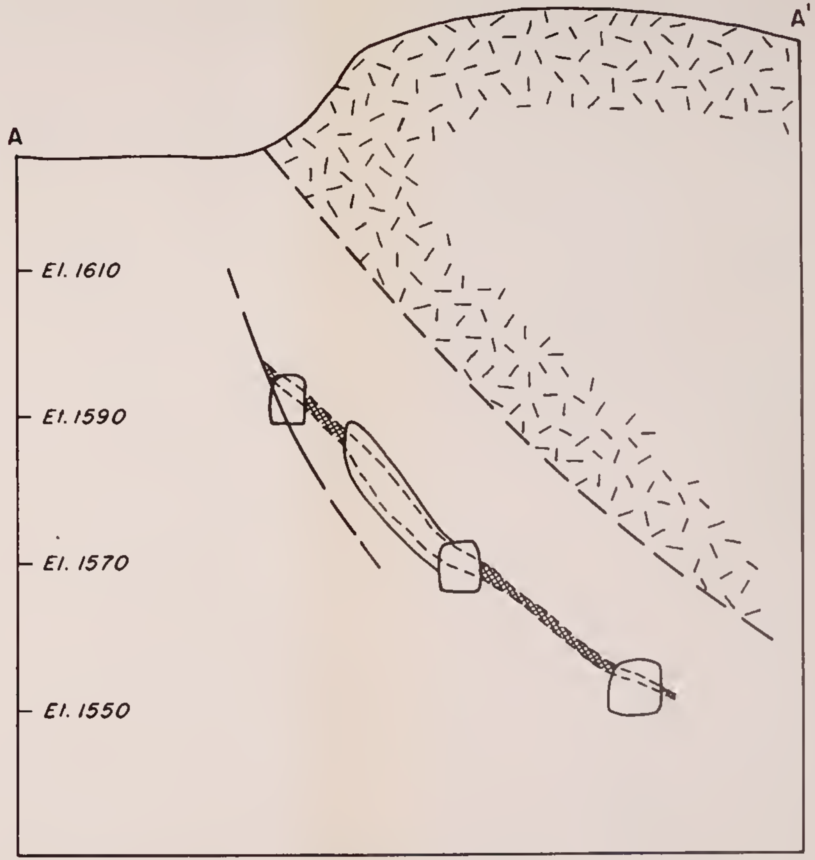
STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BULLETIN 134, PART I
PLATE 10



DATUM ASSUMED
JUNE 1943



SECTION A - A'

15 feet, a width of 35 feet, and a length down the dip of 50 feet. Most of the ore has been removed, but some still remains in the west face, in the backs, and along the southeast face of the stope, where a thin lens of chromite up to a foot in thickness continues beyond the present workings and may possibly connect with the No. 1 ore body. Some of the ore in this body was so friable that on blasting and handling it broke down to a granular powder. A vertical sheet of serpentine, which appears to be the result of shearing, nearly cuts the mass in two. To judge from recorded assays the ore in this pod was the best that has been taken from the mine; it contained 47 percent $Cr_2O_3$ and had a Cr/Fe ratio of about 2.7.

Ore body No. 3 is separated from the No. 2 ore body by a split of sheared serpentine, which in places is only a foot or so thick; the two bodies may originally have formed a single pod, subsequently sheared apart. The No. 3 body is 30 feet long, 20 feet wide, and about 7 feet in maximum thickness. Nearly all of the ore has been removed, but a narrow lens continues up dip beyond the workings in the east face of the stope. The ore is similar in appearance and grade to that found in ore body No. 2.

Ore body No. 4, which lies southwest of ore bodies Nos. 1, 2, and 3 overlaps the No. 5 and No. 6 ore bodies, is more lens-like than any of the others found in the western ore zone. It is estimated to be 190 feet long down the dip and 55 feet in maximum width, and it is known to have a maximum thickness of about 12 feet. This ore body has never been completely explored, and it may consist of two or more lenses on a line extending down the dip. The thinner parts of ore have been crushed by shearing movements and diluted with serpentine. Small irregular masses of rodingite project into the ore, especially along the contacts in the vicinity of the pillar on the 1540 foot level and in the area penetrated by diamond-drill holes 4 and 5 in the west tunnel. The ore in this lens is rather variable in grade; the richest, in the eastern part of the workings, contains 45 percent $Cr_2O_3$ and has a Cr/Fe ratio of 2.5, while the poorest. in the western part of the body explored by holes 4 and 5, contains 38 percent $Cr_2O_3$ and has a Cr/Fe ratio of 2.0. Both above and below this lens a few small outlying masses of chromite have been found by diamond drilling and by drilling with sectional steel.

Ore body No. 5 lies under the No. 4 ore body and just northwest of the No. 6 ore body, from which it is separated by a split of serpentine about 4 feet thick. It is estimated to be about 80 feet in both length and width, and its measured maximum thickness is 23 feet. Most of the ore is free from serpentine, but several serpentine splits and small dikes of rodingite were encountered in mining. A vertical fault striking N. 70° W. offsets the northern segment of the pod several feet westward. Considerable ore remains in the lower part of this pod, in the west face and the back of the stope.

Ore body No. 6 was the largest one in the west ore zone; it has a maximum length down-dip of 120 feet, a width of 75 feet, and a thickness of 28 feet. Its northern edge overlapped the southeast edge of the No. 4 ore body, and the two were separated in some places by only a foot of sheared serpentine.

*Other Deposits.* During the first World War some ore was mined from two small pods about 500-600 feet southwest of the present work-

15 feet, a width of 35 feet, and a length down the dip of 50 feet. Most of the ore has been removed, but some still remains in the west face, in the backs, and along the southeast face of the stope, where a thin lens of chromite up to a foot in thickness continues beyond the present workings and may possibly connect with the No. 1 ore body. Some of the ore in this body was so friable that on blasting and handling it broke down to a granular powder. A vertical sheet of serpentine, which appears to be the result of shearing, nearly cuts the mass in two. To judge from recorded assays the ore in this pod was the best that has been taken from the mine; it contained 47 percent $Cr_2O_3$ and had a Cr/Fe ratio of about 2.7.

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*Other Deposits.* During the first World War some ore was mined from two small pods about 500-600 feet southwest of the present workings. A caved 10-foot shaft and a shallow pit remain on each of these pods, but no ore remains in sight and the attitude and size of the pods are unknown. Specimens of ore remaining on the dump consist of nearly massive medium-grained chromite containing a little interstitial talc and serpentine.

*Reserves.* None of the ore remaining in the French Hill property can be measured; all the estimated reserves must be classed as indicated or inferred. Unmined ore visible in the walls and faces of various stopes have been classed as indicated, though some of it probably cannot be extracted at a profit. Inferred ore is that which there is reason to believe, from geologic evidence, may be found in places where it can be mined. The shapes and sizes of ore bodies classed as inferred are of course uncertain. In all calculations 9 cubic feet of ore in place is assumed to weigh a long ton.

Total reserves in the east ore zone are estimated to be 200 tons. Drilling in that zone did not alter previous estimates, but it placed them on a more factual basis. Since most of this ore is only 1 to 2 feet or less in thickness, it is doubtful whether much of it can be mined profitably.

The following estimates of reserves in the western zone were calculated from measurements of numerous geologic sections and plans drawn through the ore bodies on the basis of information available August 15, 1944.

*Chromite reserves in ore bodies of the western zone—(long tons)*

| Ore body | Indicated ore | Inferred ore | Total reserves |
|---|---|---|---|
| No. 1 | --- | 270 | 270 |
| No. 2 | 60 | 100 | 160 |
| No. 3 | 5 | 10 | 15 |
| No. 4 | 310 | 3010 | 3320 |
| No. 5 | 300 | 1470 | 1770 |
| No. 6 | 75 | 545 | 620 |
| Totals | 750 | 5405 | 6155 |

### Star and Rough and Ready Claims (29)

In sec. 31, T. 17 N., R. 2 E., is a group of claims held by Elmer Smith, comprising the Star Nos. 1 and 2 and the Rough and Ready Nos. 4 and 5. These claims have been prospected by several pits from 4 to 7 feet deep.

Several small boulders of chromite, associated with the placer gravels laid down during the Klamath erosion cycle, led to the staking of these claims, on the mistaken supposition that the chromite was float derived from underlying ore bodies. Only one of the pits, however, uncovered any ore that was not visible on the surface, and all that this pit revealed was one more boulder of massive chromite, lying 4 feet below the surface but 2 feet above the serpentinized bedrock, in decomposed gravels consisting of pebbles and boulders of diorite, metavolcanic rocks, and serpentine. Here and there erosion has removed the old gravels and exposed the serpentine, but no chromite has been found in place, and the chances of finding any are no better in this locality than in any equally large area of serpentine chosen at random. It might be possible, however, to collect several tons of chromite float from this area.

## Gordon Mountain-Fox Ridge Area

### General Features

The Gordon Mountain-Fox Ridge area lies east and southeast of the French Hill area. It extends southward from the Middle Fork of Smith

River, where it is 5 miles wide, to a rounded termination about 1 mile wide on Fox Ridge, 8 miles from the river (see pl. 1)..

Ten occurrences of chromite have been opened up and mined in this area. In order to reach the area one takes the French Hill-Bear Basin road, which branches from Highway 199 about 70 miles southwest of Grants Pass, then turns off, 9½ miles from the highway, into the Big Flat road. Both these are graded Forest Service roads, but they are dirt roads and impassable during prolonged wet weather. Steep truck trails lead from them to the mines.

The area is in the tapering southern end of the Josephine peridotite mass. It is bounded on the east for about 2 miles south of the river by metavolcanic rocks, and farther south by slate, shale, and sandstone of the Galice formation. These rocks dip from eastward to southward along the southern end, where their strike swings from south to west. Much of the eastern contact is a fault dipping steeply eastward. On the west the peridotite is in contact with Galice metavolcanic rocks and with later intrusive rocks. Thick brush cover and slumping make it difficult to be certain of the attitude of the western contact, but in places it can be seen to dip eastward. Part of it is faulted, and slivers of diorite are faulted into the peridotite. There is a strong fault trending northwest in the saddle between Upper and Lower Coon Mountain.

The varieties of peridotite in this area have not been separately mapped. Here as elsewhere, the dominant variety is a medium-grained saxonite, which is only partially serpentinized except where it is highly sheared. No large areas of dunite were seen, and there do not appear to be many areas of it as much as 100 square yards in extent.

### Zinc Saddle Claim (30)

The Zinc Saddle claim is in the SE¼ sec. 25, T. 17 N., R. 2 E., 8 miles from Highway 199 by way of the French Hill-Bear Basin road. During the first World War this property was owned and operated by the California Chrome Company as part of a group of holdings called the Gordon Mountain chrome mine. This group as a whole yielded 179 long tons of ore, but how much of it came from the Zinc Saddle claim is not known. The claim is now owned by O. L. Linn, L. F. Linn, and Mike Sciuto, of Coquille, Oregon.

The workings, which are on a steep north slope 1000 feet north of Zinc Saddle and 200 feet below it, consist of five openings, lying within a distance of 500 feet along a zone of intense shearing, which trends about N. 20° W. and dips steeply toward the west, being roughly parallel to the contact 4500 feet to the west. Zinc Saddle is a result of erosion in this shear zone. The lowest opening examined is at an altitude of 2150 feet; it is a trench 100 feet long trending due south. Higher up the slope is a caved adit trending S. 45° W. The other openings are also caved and were not examined. Some bulldozing was done on the property in 1942, but no chrome pods worthy of note were uncovered.

### Coon Mountain Group (31)

The Coon Mountain group consists of three claims, two of which were located by Bert McBride and the other by George S. Shicora. In 1942 all three claims were being operated under lease by C. H. McClendon, who had built 4.5 miles of steep truck trail joining the French Hill-Bear Basin road 8.5 miles from Highway 199. The claims

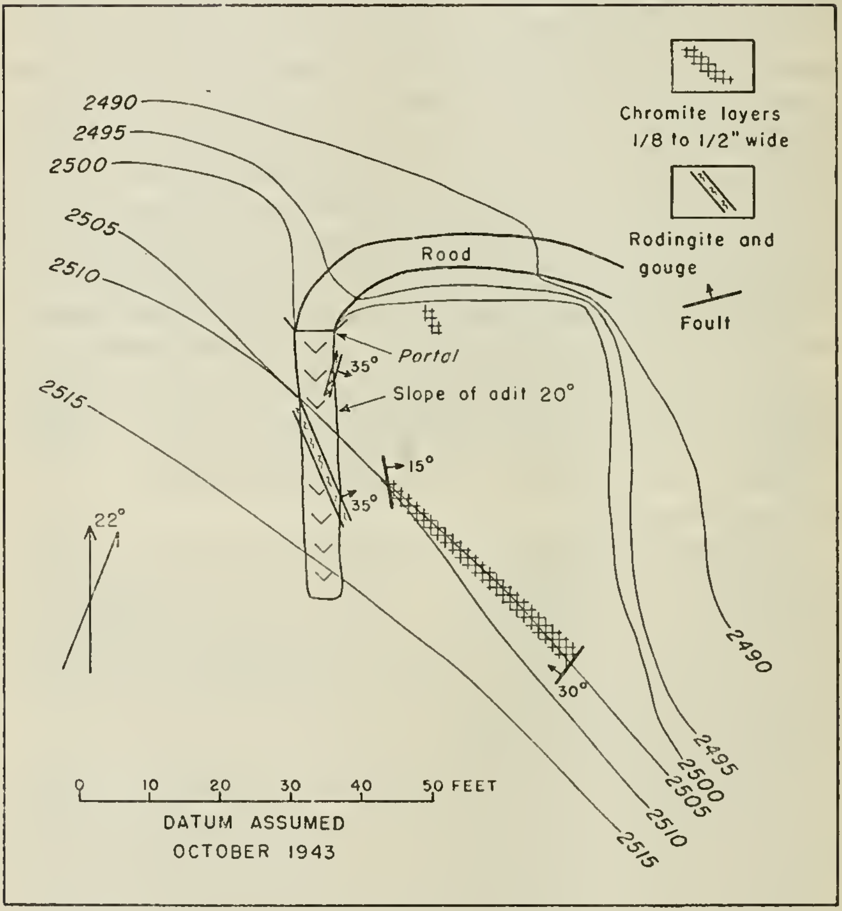

FIG. 7. Sketch map of Coon Creek No. 1 claim

are in sec. 11, T. 16 N., R. 2 E., on the west slope of Lower Coon Mountain, above Craig Creek, at an altitude of 2700 feet. The slope is steep and there is no water nearby. The deposit is a few hundred feet from the west contact of the peridotite. The principal country rock is relatively fresh saxonite. An open cut exposes a narrow shear zone trending N. 60° W. and dipping 60° NE. Some lump ore was on the dump of this cut when the property was visited, and McClendon reports that he shipped about 12 long tons in 1943. Half a mile to the north, at the end of the road and at an altitude of 2650 feet, is another open pit in barren fresh saxonite.

### Coon Creek No. 1 Claim (32)

The Coon Creek No. 1 claim was located by Christensen, Nelson and Viemann in 1942 and was bought by C. H. McClendon in 1943. It is in sec. 12, T. 16 N., R. 2 E., on the south side of a short gulch draining eastward into Coon Creek, which is a perennial stream with a good flow of water. The mine lies just below the flat top of the hill and is at an altitude of 2500 feet. A bulldozer cut, extending 125 feet along the hillside and having a maximum depth of 10 feet, exposes bedrock for a width of 30 feet (see fig. 7). In the middle of this cut an incline has been driven 40 feet southward on a 20° slope.

The country rock is a coarse saxonite enclosing roundish masses of dunite. The incline cuts two strong shear zones, one striking N. 5° E. and dipping 35° E., the other striking N. 10° W. and dipping 55° E. The latter contains a sheet of white clayey material, which pinches and swells, its thickness varying from a few inches to 2 feet. This material may have been derived from dike rock, or it may be very thoroughly altered slickentite. Disseminated ore extends southeastward from the incline for 50 feet, to a shear zone striking N. 30° E. and dipping 30° NE. which cuts it off.

Some of the ore is banded, being made up of layers of ore an eighth of an inch to half an inch thick alternating with layers of barren dunite. The chromite is an original mineral of the dunite. A grab sample from a small pile of ore has been analyzed by M. K. Carron, with the following results:

| Concentrate | | | | Ore | | | | |
|---|---|---|---|---|---|---|---|---|
| Cr% | Fe% | Cr/Fe ratio | $Cr_2O_3$% | Cr% | Fe% | Cr/Fe ratio | $Cr_2O_3$% | Chromite % |
| 31.58 | 14.31 | 2.21 | 46.15 | 16.75 | 9.35 | 1.79 | 24.49 | 53.1 |

The Metals Reserve Company gives the following figures for ore shipped from this property to their stockpile at Grants Pass in 1943:

| Long tons | $Cr_2O_3$% | Fe% | Cr/Fe ratio |
|---|---|---|---|
| 12.6 | 41.19 | 11.80 | 2.39 |
| 19.0 | 39.96 | 11.45 | 2.39 |

Geological evidence does not indicate that the property contains more than a few hundred tons of concentrating ore; no hand-cobbing ore is in sight.

### Cooncan Claim (33)

The Cooncan claim has not been mined during the present war and therefore was not visited in the course of this investigation. It has been described by Allen[35].

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[35] Allen, J. E., op. cit., p. 121.

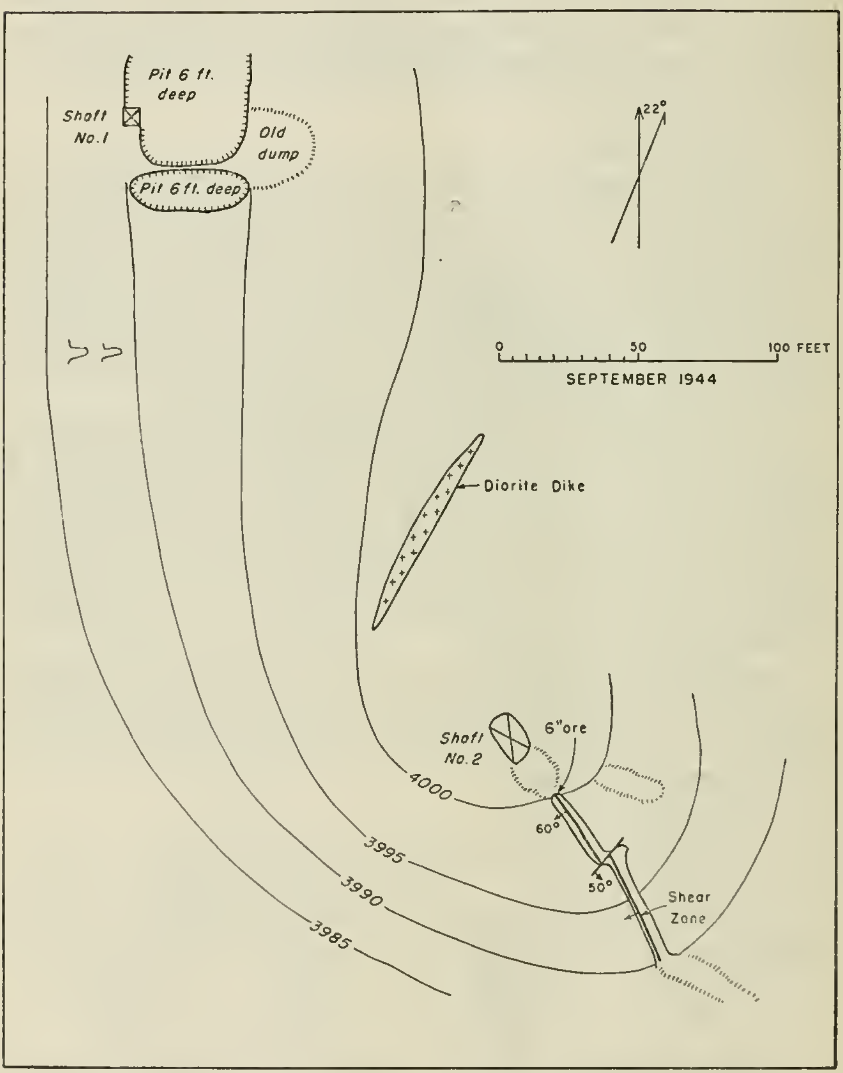

FIG. 8. Sketch map of the Apex claim, Del Norte County, California

### Sunset (Darnell) Claim (35)

The Sunset claim, in sec. 5, T. 16 N., R. 3 E., lies on the west side of Gordon Mountain, just below the crest, at an altitude of 4100 feet. It appears to have been formerly called the Darnell mine, and during the first World War the Darnell mine formed part of the Gordon Mountain Chrome Mines, held by the California Chrome Company. The claim was mined by C. H. Bennett in 1941 and 1942.

Caldwell visited the property in July 1918. His account of it does not seem altogether clear, but the gist of it appears to be as follows:

The ore occurred in kidneys aligned about north and south. One of these kidneys had been trenched for a length of 60 feet and to a maximum depth of 15 feet, and ore was exposed in the bottom of the trench for a width of 8 to 12 feet. Twenty-five feet south of the north end of the trench an inclined shaft extended 25 feet down the dip. Four feet of homogeneous ore was exposed in the back of the incline, above 6 feet of ore mixed with serpentine. The bottom of the shaft appears to be in the south end of the ore body. Caldwell estimated that 900 tons of ore had been broken and blocked out, and that there was 500 tons of probable ore.

When the claim was visited in August 1944, it could be seen that a strong shear zone striking N. 35° W. and dipping 75° NE. had been mined from an open cut for a length of 95 feet. The cut was partly filled, but for a length of 40 feet it was still 18 feet deep, though it was only 6 feet deep in the northern 30 feet and the southern 25 feet. Its width reached a maximum of 8 feet at the original surface of the ground, averaged 5 feet, and pinched to 2 feet at the top of the fill. No ore was seen in place, but a few hundred pounds of massive and disseminated ore lay on the dump.

Caldwell's estimates, both of broken and blocked out ore in sight and of probable ore, seemed over-optimistic. Bennett produced 82 long tons of ore in 1941 and 1942; 82 long tons of ore were hauled from the dumps in 1939; and in 1936 and 1937 C. O. Morelle sold 215 long tons of ore from the dumps to C. Fies of Roseburg. A part of the ore from the Gordon Mountain Chrome Mines' total production of 179 long tons may have come from this mine, but it can hardly have been a large part, for no road to the mine was completed until just before the Armistice. It does not seem likely that the total production from this property has greatly exceeded the sum of the known shipments, which is 379 long tons.

### Apex (Goose Egg) Claim (34)

The claim now to be described has been called the Apex, but the claim notice for 1942-43, which was the only notice seen on the claim when it was visited in September 1944, gave the name as Goose Egg and the holder as Albert C. Ashcraft. The claim is in sec. 8, T. 16 N., R. 3 E., on the top of Gordon Mountain, at an altitude of 4000 feet. It is 14 miles from Highway 199 by way of the Big Flat Forest Service road, which runs along the west side of the claim. A shipment of 10.19 long tons delivered to the Metals Reserve stockpile at Arcata by Griffith in 1943 is said to have come from this property.

A sketch of the workings is shown in fig. 8. They include two pits, two shafts, and a short adit. From what is now exposed it is evident that the ore occurred in a shear zone trending N. 35° W. and dipping 60° SW. From the material on the dumps the rock in the shear zone appears to have been slickentite. It is cut by faults of small displacement that strike N. 46° E. and dip 50° SE. The shafts are filled with water, but it appears from what can be seen in shaft No. 2 that the ore plunges to the northwest. Lumps of massive ore and some disseminated ore were found on the dump. The 10 tons shipped to the stockpile assayed 37.60 percent $Cr_2O_3$ and 10.74 percent Fe, and had a Cr/Fe ratio of 2.40.

### Big Dipper (Camp Seven, Rowan) Claim (37)

The claim variously called the Big Dipper, Camp Seven, and Rowan lies in the SW¼ sec. 7, T. 16 N., R. 3 E., at an altitude of 3100 feet, on the steep east slope of Gordon Mountain and near the head of Gordon Creek. It was leased early in 1942 by C. H. Bennett and J. K. Remsen from Mrs. Floyd Peuten. It can be reached from Highway 199 by following the French Hill-Big Flat road for 15 miles and a truck trail for 0.7 mile. When the property was visited in 1942, the largest opening was a quarry cut 122 feet along the face of the mountain, 1000 feet from the end of the trail and 400 feet lower. A cable tram with a bucket of 1500-pound capacity was used to carry ore from the quarry to the bunkers at the end of the road. The quarry extended into the mountain for 50 feet and was 27 feet deep at the back. There was a small open cut 50 feet southwest of the southern end of the quarry and 48 feet below it, and other short shallow cuts had been dug in the mountain side. Three of these cuts yielded 150 long tons of ore in 1943.

The workings are in peridotite, a mile northeast of the contact. The ore at the quarry occurs in a shear zone striking N. 15° E. and dipping 20° SE. It forms intensely faulted lenses, whose outlines could not be fully traced. Every joint face showed evidence of movement, being coated with clay, soapy gouge, or slickentite, and many joints could be seen to offset veinlets of pyroxene. The shear zone is 3 feet wide; its length and depth were not determined. The surrounding dunite is highly serpentinized but not shattered; where freshly broken it has a bluish-green color and is slightly translucent.

Some magnesite lenses up to 6 feet in length and 4 inches in width crop out 20 feet north of the quarry. Chromite was seen in only one place; it was 2 feet wide and massive. The ore on the dump consisted of small lumps of chromite frozen to serpentine.

During the first World War this property formed a part of the Gordon Mountain Chrome Mines, owned by the California Chrome Company, and its production has not been recorded separately. About 150 long tons of ore are said to have been shipped in 1937. In 1941, 77 tons were shipped, of which one lot assayed 41.32 percent $Cr_2O_3$ and 11.04 percent Fe, and another 43.0 percent $Cr_2O_3$ and 12.04 percent Fe. Shipments to the Metals Reserve Corporation during 1942 and 1943 totaled 339 long tons. Analyses of ore shipped in 1943 gave 42.70 to 43.54 percent $Cr_2O_3$, 11.16 to 11.95 percent Fe, and a Cr/Fe ratio of 2.49 to 2.62. A partial analysis of a sample collected from the dump in 1942 follows:

*Sample F.G.W.-4-42*

Analyst M. K. Carron

| CONCENTRATES | | | | ORE | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cr% | Fe% | Cr/Fe ratio | $Cr_2O_3$% | Cr% | Fe% | Cr/Fe | $Cr_2O_3$% | Chromite% | $SiO_2$% |
| 33.83 | 12.98 | 2.60 | 49.43 | 29.52 | 12.62 | 2.34 | 43.14 | 87.2 | 4.72 |

### Patterson No. 1 Claim (38)

The Patterson No. 1 claim is in sec. 18, T. 16 N., R. 3 E., on the south slope of Gordon Mountain, at an altitude of 3500 feet. It is reached by a steep road half a mile long, which meets the Big Flat road 16.5 miles from Highway 199. This property was mined in 1941 by C. H. Bennett, who shipped 91 long tons of ore to the U. S. Vanadium Corporation in that year and a total of about 60 long tons in 1942 and 1943.

The dominant country rock in this area is fresh saxonite, in which the proportion of enstatite varies noticeably; in places enstatite may make up as much as 30 percent of the rock. On a slope above the diggings there is considerable fresh dunite, which breaks in blocks several feet on a side. The dunite usually contains 1 or 2 percent of enstatite. No ore was seen in place except for a few inches of disseminated ore exposed alongside the road 600 feet east of the tunnel.

The principal opening on the claim is an adit, 3160 feet above sea level and 6 feet above the road. Apparently the main part of the adit trended north, but the longest working now open is a drift trending N. 60° W., which takes off from a short crosscut 5 feet in from the portal and 10 feet west of the main course of the adit, and is said to have followed the ore for 70 feet. A hundred feet northwest of the portal and 10 feet higher is a trench running a few degrees east of north and 20 feet long, which crosses some well-marked fissures that strike N. 55° E. and dip 70° E. Columnar crystals of amphibole coat the walls of these fissures.

No ore was seen in place. The ore on the dump is in part massive, but part of it has a platy structure. In the platy ore, dunite encloses parallel pencils of massive chromite, which are several inches long, irregular in cross-section, and not more than half an inch thick. Mr. Bennett says that the ore was of high grade.

### Camp Eight (St. Patrick) Claim (39)

The Camp Eight claim, sometimes called the St. Patrick, is near the center of the east half of sec. 19, T. 16 N., R. 3 E., a short distance uphill from a spring on the Big Flat road and 15½ miles from the junction of that road with Highway 199. The claim lies on a steep south-facing slope, at an altitude of 2750 to 3000 feet. The Camp Eight mine was opened during the first World War by the California Chrome Company and formed part of their Gordon Mountain Chrome Mines. It is reported that 100 long tons of ore was left on the dumps in 1918, and that in 1937 this ore was sold by C. O. Morelle to C. Fies of Roseburg, Oregon, who shipped it in the same year. Since 1942 the claim has been owned and operated by C. H. Bennett and J. K. Remsen. They have produced 27 long tons of ore, which assayed 40.4 percent $Cr_2O_3$, and had a Cr/Fe ratio of 2.35.

There is conspicuous evidence of landsliding and creeping in this vicinity. The contact of the peridotite with metavolcanic rocks extends westward from the mine, at a distance of a few hundred to 2000 feet. The peridotite exposed on the claim is slickentite.

The old workings consist of four adits, all at the same level and all caved, spaced around the ridge at intervals of about 40 feet. Bennett drove a drift 20 feet into ore that consists of angular and partly rounded lumps of medium- to high-grade chromite, in a gray, flaky serpentine matrix deeply stained with iron oxide. Many of the lumps have slickened surfaces encrusted with uvarovite and kammererite. Pieces of ore, ranging from grains a sixteenth of an inch in diameter to lumps weighing 100 pounds, are found in the heavy overburden of soil, which grades downward into shattered slickentite.

### Sunrise Claim (40)

The Sunrise claim, like most of the other claims on Gordon Mountain, was held during the first World War by the California Chrome Company as part of the Gordon Mountain Chrome Mines. It lies in sec. 19, T. 16 N., R. 3 E., near the brow of a ridge west of Hurdygurdy Creek, at an altitude of 2500 feet, and is reached from Highway 199 by following the French Hill-Big Flat road for 18 miles and a short, steep spur road for 0.7 mile. A little ore is said to have been mined from this property. Mr. W. E. Gilmore located the claim in 1941 and has mined it since then. He reports that he mined and sold about 400 long tons of ore to the Union Carbide Company in 1941 and produced 168 long tons in 1942. This ore averaged 50.5 percent $Cr_2O_3$ and had a Cr/Fe ratio of 2.82. Work was suspended in 1943 but production was resumed in 1944.

The only trace of the 1918 workings is the most northerly adit, which is about 50 feet south of the north end of the bulldozer bench. It starts with a course of S. 60° W. but is caved. In 1941 Gilmore drove Tunnel No. 1, which started in ore 75 feet S. 30° W. from the old adit. He then bulldozed a bench along the ridge for a length of 320 feet. Later he sank, in Tunnel No. 1, a winze extending 30 feet down the dip in ore, and drove what is called Tunnel No. 2 from a point 105 feet south of Tunnel No. 1. Tunnel No. 2 is strictly speaking an incline, 30 feet long and extending southwestward on a slope of about 15°. Ore was stoped from both these openings. When the mine was shut down, in July 1944, ore had been mined to a depth of about 70 feet down the dip from the croppings, and the dunite layer had been opened up for 320 feet along the hillside. Some ore was left, but the cost of mining had become prohibitive.

The workings are in peridotite, a little less than 1000 feet north of the contact. The peridotite is mainly serpentinized saxonite, but the chromite is in a lens of serpentinized dunite about 10 feet thick, which strikes N. 60° W. and dips 15° SW. Both the dunite and the ore are cut by a few irregular dikelets of rodingite, none more than a few inches thick. The chromite forms a series of discontinuous, partly overlapping lenses and irregular pods, from 6 inches to 6 feet thick and up to 10 feet long, strung out along the dunite lens. The longest dimension of each lens or pod usually extends down the dip. The ore is fine-grained nearly pure chromite containing a little uvarovite and kammererite. The contacts of the ore with the serpentine, though rather sharply defined, are not sheared and the ore does not break cleanly from the walls.

A partial analysis of clean ore made in the laboratory of the Geological Survey gave the following result:

*Sample F.G.W.–3–42*

Analyst M. K. Carron

| CONCENTRATES | | | | ORE | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cr% | Fe% | Cr/Fe | $Cr_2O_3$% | Cr% | Fe% | Cr/Fe | $Cr_2O_3$% | Chromite% | $SiO_2$% |
| 34.48 | 12.43 | 2.77 | 50.38 | 32.13 | 12.24 | 2.63 | 46.98 | 93.3 | 3.08 |

A sample from a shipment was analysed by Abbot Hanks and gave:

| | | | |
|---|---|---|---|
| $Cr_2O_3$ | 46.35 | P | 0.037 |
| $SiO_2$ | 3.66 | S | 0.045 |
| Fe | 13.03 | Cr/Fe | 2.43 |

### Gilmore Claim (41)

The Gilmore claim is in sec. 30, T. 16. N., R. 3 E., on the steep southeast nose of a ridge below Gordon Mountain, at an altitude of 1980 feet. A rough dirt road half a mile long runs from the workings to Van's Camp on the Big Flat road. The chromite on this property was discovered during the first World War. W. E. Gilmore mined and shipped some ore in 1942 and 1943.

The workings, which lie 1000 feet west of the peridotite contact, consist of an inclined cut trending N. 55° W. and dipping 45° SW. The cut is 33 feet long and is caved 25 feet from the surface, at which depth it is 5 feet wide. The peridotite is sheared but not flaky; it is serpentinized and contains some talc. A few inches of ore is exposed in the south end of the cut. The ore found on the dump is coarse-grained and frozen to the wall rock.

### Grumpy Claim (42)

The Grumpy claim is in sec. 30, T. 16 N., R. 3 E., on the steep west slope of Hurdygurdy Gulch, 250 feet above the creek and at an altitude of 1500 feet. It can be reached by way of a bulldozer trail that joins the French Hill-Big Flat road near Van's Camp.

The deposit was discovered during the first World War, but no ore was mined at that time. In 1941 C. H. Bennett opened up the property and shipped some ore to the Vanadium Corporation of America, and in 1942 he and J. K. Remsen shipped ore to the Metals Reserve Company at Grants Pass. No record of production could be obtained, but Mr. Bennett estimates that it was about 150 long tons.

The workings consist of an open bulldozer cut 110 feet long, 35 feet wide, and 25 feet in maximum depth, and two short adits about 15 feet apart. The north adit is 15 feet loug; the south adit was driven only 10 feet, and at its inner end a winze pitching 70° was sunk to a depth of at least 15 feet. The face of the cut was badly caved when visited in September 1944.

The ore deposit, which lies within a few hundred feet of the peridotite contact, consists of a northward-trending lens of chromite which originally dipped about 70° W. but has a flatter dip near the surface because of hillside creep. The prevailing country rock is highly serpentinized saxonite, considerably sheared near the ore. Only a little dunite is present. No ore was seen in place except in the south adit, where one could see 9 inches of medium-grained chromite mixed with a little kammererite, talc, magnesite, and serpentine. On the dump there is some banded material, made up of layers from one to several inches thick, in which nearly barren dunite alternates with ore containing 10 to 20 percent of disseminated chromite.

### Lone Grave Nos. 1 and 2 Claims (43 and 44)

The Lone Grave No. 1 and No. 2 claims are in T. 16 N., R. 3 E., on the southwest slope of Fox Ridge. The Lone Grave No. 1 claim is near the line between secs. 29 and 32, at an altitude of 2500 feet, and the Lone Grave No. 2 is in the northwest corner of sec. 33, at an altitude of

2500 feet. Both were located by William Stevens and R. R. Stevens in the spring of 1942, and were leased by J. K. Remsen and C. H. Bennett during 1942 and 1943. They are about 2 miles by trail from the end of the Big Flat road, which is 40 miles from Highway 199.

The claims lie 2000 to 3000 feet northwest of the peridotite contact. The peridotite is here about 15,000 feet wide and is probably in an anticline and far below its crest. The predominant country rock is a relatively fresh saxonite, enclosed in which are scattered irregular masses of dunite; the ore bodies are all in dunite.

In the Lone Grave No. 1 claim, which is on the old upland surface, the peridotite is covered with soil. Two shallow trenches have been dug where chromite float was found, and about 200 pounds of ore has been recovered from the soil.

The Lone Grave No. 2 claim contains an ore body about 30 feet long and 10 feet in maximum width, exposed in several open cuts. This ore body consists of high-grade stringers and small pods of massive chromite enclosed in disseminated ore. The ratio of low-grade disseminated ore to the high-grade ore varies, at a rough estimate, from 1:1 to 1:2. An obscure layering in the disseminated ore strikes about N. 25° E. and dips 75° SE. A diorite dike cuts off the ore on the northeast, and the hillside at the southwest end is so steep that the ore cannot continue far in that direction.

About 7 or 8 long tons of ore have been mined from this claim. Assays of two specimens of the ore gave (1) 45.56 percent $Cr_2O_3$ and 11.44 percent Fe; (2) 39.41 percent $Cr_2O_3$ and 14.25 percent Fe.

Assuming that the ore body is 30 feet long, has an average width of 6 feet, and extends to a depth of 15 feet, the indicated reserves are 270 short tons of ore, of which 150 to 180 tons could probably be sorted to shipping grade.

### Stevens No. 2 Claim (45)

The Stevens No. 2 claim is near the Lone Grave claim, in the E$\frac{1}{2}$ SW$\frac{1}{4}$ sec. 28, T. 16 N., R. 3 E., and was located by the Stevens brothers at the same time. The deposit, which is on the steep rocky slope of a short gulch tributary to Jones Creek and is well exposed, consists of a series of small pods of high-grade ore, strung out along a shear zone that trends N. 10° E. and dips 60° E. Some of the pods are connected by thin stringers of ore. In some places the chromite breaks clean from the enveloping dunite and shows slickensided surfaces coated with serpentine and kammererite, but in most places it is frozen to the dunite wall. Ten or 12 short tons of ore has been mined, and about 5 short tons of ore is in sight. More pods of ore could probably be found by further developing work, but underground mining would soon have to be resorted to and might not be profitable. A sample of the ore assayed as follows:

*Sample F.G.W.-1-42*

Analyst M. K. Carron

| CONCENTRATES | | | | ORE | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cr% | Fe% | Cr/Fe | $Cr_2O_3$% | Cr% | Fe% | Cr/Fe | $Cr_2O_3$% | Chromite% | $SiO_2$% |
| 33.31 | 13.76 | 2.42 | 48.68 | 29.52 | 12.33 | 2.39 | 43.15 | 88.6 | 4.82 |

### Muzzle Loader (Stevens No. 1) Mine (46)

The Stevens No. 1 claim, containing what is commonly called the Muzzle Loader mine, is in the SE¼ sec. 4, T. 15 N., R. 3 E., on the steep south slope of Muzzle Loader Creek, at an altitude of 2200 feet. It is accessible from Highway 199 by way of the French Hill-Big Flat road, a distance of 33 miles. From the end of this road, on Jones Creek, 2 miles of steep truck trail climb 1000 feet to the mine. It was located, together with the Stevens No. 2 and the Lone Grave Nos. 1 and 2, by R. R. Stevens and William Stevens, of Big Flat, California, in the spring of 1942, and was leased shortly thereafter to J. K. Remsen and C. H. Bennett, who mined it during 1942 and 1943.

The workings are in a tongue of peridotite that extends from the Coon Mountain-Fox Ridge body southward across Jones Creek. Contacts of peridotite with the Galice formation lie about 1000 feet to the west and the same distance to the east. Much landsliding has taken place in the peridotite and in the Galice slates as well. Large open cracks were found in the rock exposed in the workings, and the ore itself is so jumbled that one cannot be quite sure of its original shape and attitude. It appears, however, to have formed a number of tabular pods of coarse-grained massive chromite, scattered at random in a zone that strikes N. 60° E. and dips 45°-60° NW. The largest body ranged in thickness from a few inches to 4 feet and averaged about 3 feet. The ore breaks easily from the dunite wall rock, which is serpentinized and fractured, but not thoroughly enough to be called a slickentite. Many of the lumps of chromite are coated with flakes of kammererite. Partial analysis of a sample of ore gave the following results:

*Sample F.G.W.–2–42*
Analyst M. K. Carron

| CONCENTRATES | | | | ORE | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cr% | Fe% | Cr/Fe | $Cr_2O_3$% | Cr% | Fe% | Cr/Fe | $Cr_2O_3$% | Chromite% | $SiO_2$% |
| 37.52 | 12.01 | 3.12 | 54.81 | 34.23 | 12.19 | 2.81 | 50.02 | 91.3 | 2.28 |

The first mining was done at the west end of an open cut. Ore was later followed into the ground by short adits, but as some of these caved the open cut was widened until, when visited in the early summer of 1943, it was 50 feet long, 35 feet wide, and from 15 to 20 feet high at the face. A short adit running N. 45° E. followed ore on the level for 30 feet (see fig. 9), and from its inner end the ore was followed downward in an inclined winze, which also trended northeast and had a slope of 25°. At the bottom of the winze, which was 35 feet long, a drift has been driven S. 45° E. for 18 feet. This drift and the adit cross a fault striking N. 60° E. and dipping steeply northwest. Ore has been stoped northwest of the adit. Fragments of ore can be found here and there in the walls of the winze and of the drift at its foot, but no ore is to be seen in the face of the drift nor in the back of any of the workings.

In August 1944 the block of ground east of the adit was explored by three holes, drilled with sectional steel from near the floor and pointed upwards at an angle of a few degrees. Hole No. 1, 12 feet from the portal, is 12 feet long; No. 2, at the head of the incline, is 10 feet long; and No. 3, which extends southward from the bottom of the incline, is 2 feet long. No ore was found in any of the holes.

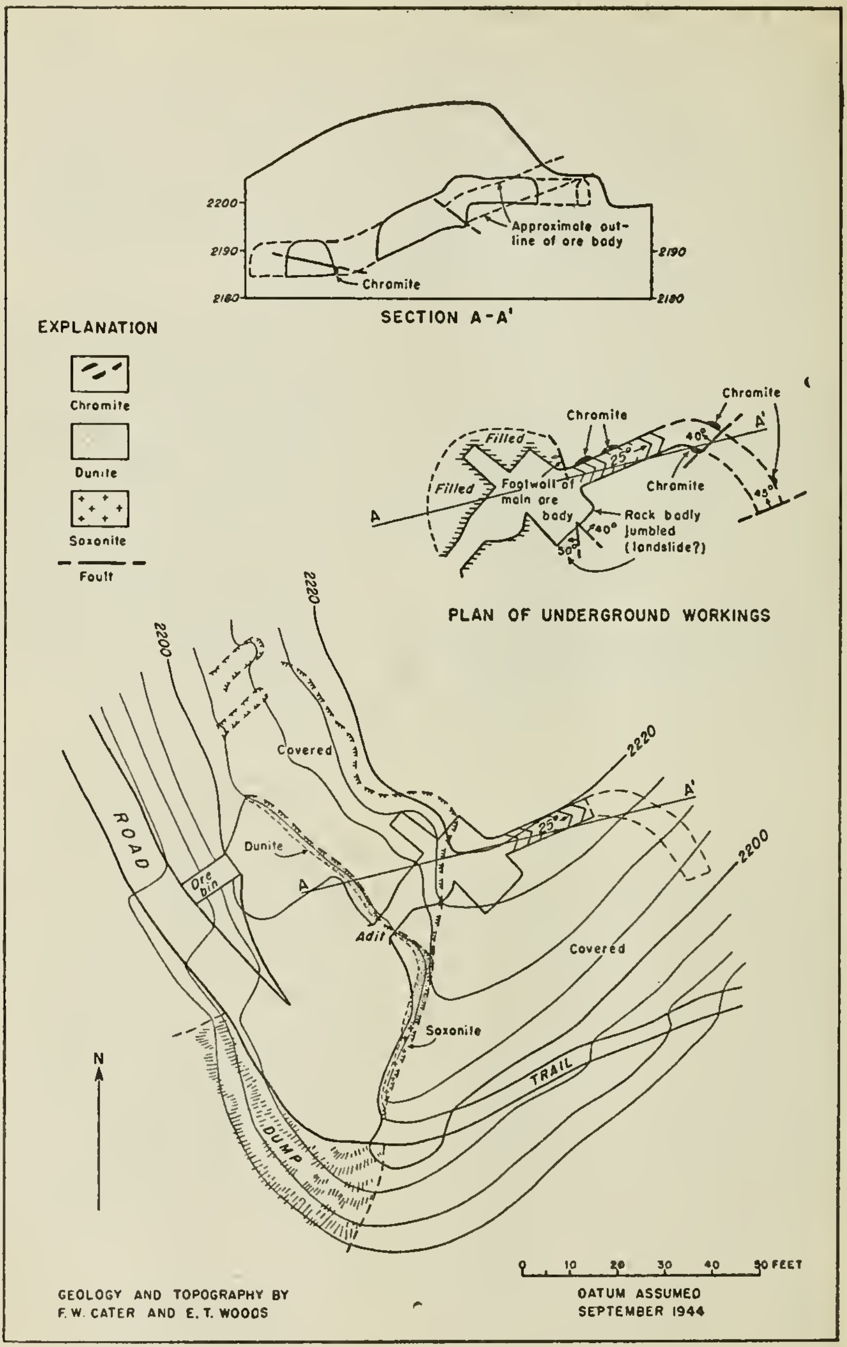

FIG. 9. Sketch map and section of the Muzzle Loader mine, Del Norte County, California

## PROPERTIES IN SOUTHWESTERN PERIDOTITE BELT

### South Fork Area

The South Fork area lies in the southwestern part of T. 16 N., R. 2 E., northeast of the South Fork of Smith River and 6 miles upstream from its mouth. A graded Forest Service road leads into the area from Highway 199, which it meets 76 miles southwest of Grants Pass. This road is on the west side of South Fork, but there is a temporary bridge on which trucks can cross the stream at low water, and from this crossing a steep truck trail 2.7 miles long leads to the top of the ridge.

On the northwest side of this area, peridotite is brought into contact with metavolcanic rocks, probably of Franciscan age, by a fault that strikes N. 45° E. and dips northwest. On the north and east the contacts are poorly exposed, but the peridotite makes a nearly vertical contact with the metavolcanic rocks. Along the South Fork the peridotite is highly serpentinized, much of it being slickentite. Where the peridotite is not so highly sheared, it is seen to be a medium-grained saxonite.

Three chromite deposits have been mined in the area, on the Fourth of July claim (48), the Hawkins claim (47), and the Contact claim (49).

#### Fourth of July Claim (48)

The Fourth of July claim is in sec. 29, T. 16 N., R. 2 E., on the north brow of the ridge between Coon Creek and the South Fork, at an altitude of 1300 feet. It was located in 1942 by C. H. McClendon, who soon opened up the deposit by making a bulldozer cut that when visited was 100 feet long, 50 feet wide and 20 feet deep. He began shipping ore late in the summer of 1944.

The deposit consists of sheared pods of disseminated ore and of almost massive chromite, enclosed in highly sheared serpentine. Individual pods exposed in the cut are 2 to 10 feet wide and up to 15 feet long. The general trend of the deposit is northwestward, but its dip is unknown. The ore is rather variable in grade, and the disseminated ore has to be sorted with special care; otherwise, as the gangue is black, lean ore can be taken for massive chromite. The massive chromite is medium-grained and mixed with more or less serpentine. The deposit contains a little kammererite and uvarovite. The mine had produced, up to September 15, 1944, 101 long tons of ore, containing 37.11 to 38.21 percent $Cr_2O_3$, and having a Cr/Fe ratio of 2.15. Reserves may amount to 200 or 300 long tons.

#### Hawkins (Billy Boy, Divide) Claim (47)

A claim in sec. 29, T. 16 N., R. 2 E., on the steep north slope of the ridge and just below the crest, at an altitude of 1340 feet, has been variously named. The late William Hawkins, who first opened it up, named it the Divide claim, though he said that early owners had called it the Billy Boy; it is now generally known, however, as the Hawkins. Hawkins leased the property to C. H. McClendon, who mined it in 1943 and produced 200 long tons of ore.

The peridotite containing the ore is highly serpentinized and much broken. When the property was visited in 1940, there were three trenches, the highest and lowest of which were 62½ feet apart. The lowest cut was then caved, but it is described by Allen [36] as follows:

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[36] Allen, J. E., op. cit., p. 121.

> "The lowermost cut is floored by ore, and its face, exposed for 16 feet in length and 5½ feet in height, is also solid chromite. At the east end however, the body appears to round off, and at the west end is dipping gently westward when it disappears. The indication is that the kidney has a cross-section of at least 20 by 10 feet and possibly much more, plunging gently southwest. The east end is broken by several closely spaced faults with displacements of only a few inches."

The middle cut, at an altitude of 1340 feet, is a trench extending S. 65° E. along the side of the ridge, 12 feet long and 3 feet wide. Massive ore was exposed all across the middle part of the trench, but the ends of trench were in serpentine.

The upper cut was filled in 1940, but Allen [37] describes it as follows:

> "The upper cut lies only 15 feet farther south, and exposes a small body 8 feet long by 4½ feet wide, whose east side strikes N. 20° E. and dips 60° E., and whose south side strikes east and dips 55° south. It can be seen that if these boundaries continue downwards, the body enlarges rapidly."

The deposit was mined with a bulldozer, and nothing can now be seen or learned regarding its structure. The ore is coarsely crystalline and massive. Lumps of it are slickensided and partly coated with uvarovite.

### Contact Claim (49)

The Contact claim, owned by C. H. Bennett, is in sec. 29, T. 16 N., R. 2 E., on the north slope of the ridge and just below the crest, at an altitude of 1300 feet. The ore occurs in slickentite, less than 100 feet from the eastern contact of the peridotite. It has been explored by two pits about 4 feet square and 3 feet deep. About three short tons of ore has been mined from each of the pits, and this ore is piled beside the pits.

## Little Rattlesnake Mountain Area

### General Features

On the top and eastern slope of Little Rattlesnake Mountain, in T. 15 N., R. 2 E., there are 18 properties that seem worthy of note. The summit is 3.244 feet above sea level, and the nearest point on the South Fork of Smith River, at the eastern base of the mountains is more than 2600 feet below. To reach this area one leaves Highway 199 at the mouth of the South Fork, which is 10 miles from Crescent City and 76 miles from Grants Pass, and follows an all-weather Forest Service road up the South Fork for 8 miles to the mouth of Rock Creek. From there a steep dirt road, not passable in wet weather, goes southward up the crest of the mountain ridge for about 5½ miles to the vicinity of the summit. The road continues in a general southeasterly direction for some 4 miles, ending at the Big Five mine, low on the eastern slope. It is 17½ miles by road from the Big Five mine to Highway 199.

The claims clustered on the gentle slope just north of the summit, in the vicinity of Soldier's Well, were actively mined during the first World War by the R. D. Adams Company, which called the properties it operated the Rattlesnake Chrome Mines. Most of the ore shipped from this vicinity since 1939 had been mined in 1918 and left on the dumps. Much of the piled-up ore had been stolen between 1918 and 1943, and for that reason, coupled with the fact that litigation over ownership has made many people secretive, the total amount of ore produced from these old workings will never be accurately known.

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[37] Allen, J. E., op. cit., p. 121.

Caldwell[38] estimated that on July 4, 1918, the area contained 400 long tons of broken ore and 500 long tons of proven ore. Allen[39] says that 425 long tons were on the dumps on July 20, 1937, and that two piles of ore along the road, one containing 125 long tons and the other 7, are supposed to have come from this area. It is safe to say that at least 1000 long tons of chromite was shipped from the area before 1942.

Very little mining has been done on these old properties during the present war. It was, however, the demand for chromium arising from this war that resulted in locating two claims about a mile and a half northwestward from the summit, and of several others lying south and east of the summit, on most of which the discoveries were made by three brothers, Albert, Homer, and J. E. Inman, in 1942.

Little Rattlesnake Mountain is in the widest part of the southwestern peridotite belt, which is here about 3 miles wide and apparently occupies the crest of the anticline. The rock is here, as elsewhere, dominantly saxonite, locally sheared. Dunite has been identified in so few places as to suggest that some of the ore may have been formed in direct contact with saxonite. That seems unlikely, however, when it is remembered that an immense majority of the chromite deposits in California and Oregon are known to be surrounded by dunite. It may be that the dunite envelopes in this area are generally thin, and where that is the case the dunite is likely to be so completely altered to serpentine that it cannot be recognized.

### Carla Claim (50)

The Carla claim is in sec. 9, T. 15 N., R. 2 E., just below the crest of Boulder Ridge and on the slope overlooking Boulder Creek, at an altitude of about 2500 feet. The deposit was discovered in the spring of 1944 by C. Stevens and J. Wilson, and they have mined and shipped 28 long tons of ore, which carried 38 to 45 percent $Cr_2O_3$ and had a Cr/Fe ratio of 2.2 to 2.8. The deposit was not visited by the Geological Survey party.

### Rattlesnake Mountain Claim (51)

The Rattlesnake Mountain claim is on top of Little Rattlesnake Mountain, in sec. 17, T. 15 N., R. 2 E. It is owned by John Smith and was leased to T. J. Rodgers, who mined and shipped 47.32 long tons of ore to the Metals Reserve stockpile in 1943. Assays of this ore range as follows: $Cr_2O_3$ 37.31 to 41.53 percent, Fe 11.70 to 11.99 percent, Cr/Fe ratio 2.13 to 2.43.

### Section Sixteen Claim (53)

"Section Sixteen" is a poor name for the claim so designated, as there are several other claims within the section. The claim is in the SW¼SW¼ sec. 16, T. 15 N., R. 2 E., on patented land. It was leased during the first World War by R. D. Adams, and it was then that practically all the mining was done. The deposits are on top of Little Rattlesnake Mountain, at an altitude of 3050 feet (see pl. 1). The largest opening is a caved shaft, 429 feet north of the common corner of secs. 16, 17, 20, and 21 and just north of the road.

The old workings consist of three openings along a northwest line. The one farthest southeast is a pit 8 feet square, exposing sheared serpentinized saxonite but no ore. The caved shaft is 75 feet to the northwest, and an irregular depression lies 75 feet farther northwest. Sheared saxonite is exposed around the shaft, but in 1943 no ore was visible. Caldwell[40], however, reported in 1918 that a body of massive chromite 20 feet long and 8 feet wide was exposed there at the surface, and that the shaft followed this ore down on an incline for 30 feet, showing solid ore on both sides and in the footwall all the way down. He described a flat, tabular body 40 feet long, 28 feet wide and 10 feet in maximum thickness, but whether this is the same body that was followed in the shaft is not clear. He also says: ''The general course of the ore deposits is northwest and southeast and dip to the northeast.'' It is uncertain whether he is giving the trend of the zone or the strike of the individual bodies. Allen[41], who visited the area in 1937, says that the ore bodies strike north and are spaced en echelon along a northwest line, and this statement is borne out by distribution of the caved workings.

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[38] Caldwell, F. B., Unpublished report, U. S. Bureau of Mines, 1918.
[39] Allen, J. E., Unpublished reports to the Rustless Mining Company.

All the ore from these deposits is coarse grained and shows but little interstitial gangue. According to Allen [42] a chip sample of the ore on the dumps assayed 41.83 percent $Cr_2O_3$. One pod may have contained as much as 500 tons.

### Deleray and Rodgers Claim (55)

The Deleray and Rodgers claim lies 1000 feet east-northeast of the Section Sixteen deposits, in the SW¼ sec. 16, T. 15 N., R. 2 E., on the east brow of the ridge, at an altitude of 3100 feet. There are two trenches on the property, both in coarse-grained peridotite. The more westerly, which trends N. 45° E. and is 18 feet long, 6 feet wide, and 5 feet deep, shows no ore in place, but in 1940 its dump contained 20 long tons of massive chromite. Many of the lumps of chromite had polished surfaces. The other trench, 100 feet southeast of the southeast end of the first, trends N. 18° W., probably along the ore body. This trench is 23 feet long and about 5 feet wide; its original depth is unknown because it is partly filled with sloughed rock. No chromite was seen in its walls, but in 1940 a dump containing 20 long tons of coarse massive chromite was still there. Much of the ore was encrusted with uvarovite. Narrow veinlets of dunite cut the massive chromite and enclose fragments of it. According to Allen [43] this ore assayed 40.04 percent $Cr_2O_3$.

### Cuneo (Inman No. 1) Mine (52)

A property near the center of sec. 16, T. 15 N., R. 2 E. has been called by various names, but it will here be called the Cuneo mine, after Leland J. Cuneo, who leased it from the Hammond Lumber Company in 1942. When the property was visited in July 1943, little could be seen except a shallow caved trench, trending N. 10° E. and 25 feet long, on the north slope of Little Rattlesnake Mountain, about 400 feet below the crest and at an altitude of 2640 feet. W. E. Gilmore described the deposit, in conversation, as being shaped like half an egg, with the bottom flat and nearly horizontal. The ore appears to have been massive and to have lain in a shear zone. Gilmore says that McClendon shipped 250 long tons of ore from this deposit to Bradley and Eckstrom in 1941, and that Cuneo shipped 33.22 long tons to the Grants Pass stockpile in

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[40] Caldwell, F. B., Unpublished report, U. S. Bureau of Mines, 1918.
[41] Allen, J. E., op. cit., p. 120.
[42] Allen, J. E., idem.
[43] Allen, J. E., idem.

1943. This ore assayed 38.03 to 39.85 percent $Cr_2O_3$, and 11.60 to 11.70 percent Fe, and its Cr/Fe ratio ranged from 2.24 to 2.33.

Heavy chromite float was seen about 1000 feet northwest of the trench and 60 feet farther down the ridge.

### Soldier's Well (McClendon) Claim (54)

A few hundred feet south of Soldier's Well, in sec. 17, T. 15 N., R. 2 E., at an altitude of 3000 feet, is a small open cut about 25 feet long, said to be on the Soldier's Well or McClendon claim. Most of the work there seems to have been done during the first World War, and only scattered fragments of massive ore remain on the dump.

### Pigeon Roost Spring Claim (60)

The Pigeon Roost Spring claim is in sec. 21, T. 15 N., R. 2 E., on the top of Little Rattlesnake Mountain, at an altitude of 2875 feet, near the head of a tributary of Rock Creek. In 1942 the Inman brothers held it by location.

When the claim was visited in September 1942, the workings consisted of a trench running northwest, 35 feet long and 6 feet deep at the uphill end. The country rock is partially serpentinized medium-grained saxonite. Well-developed joints that strike N. 45° W. and dip 35° NE. are conspicuous in the trench. Some of the joint planes are coated with small crystals of amphibole. No ore was seen in place, but judging from the ore in the dumps the chromite was frozen to the wall rock. Most of this ore is shattered, but some pieces have an imperfectly developed nodular structure. About 15 long tons of chromite that was then piled on the dump has since been shipped, but no record of individual shipments was available.

### Inman No. 2 Claim (61)

The Inman No. 2 claim, owned by the Inman brothers, is in sec. 21, T. 15 N., R. 2 E. It lies 2000 feet east of the Pigeon Roost Spring claim, just where the upland surface breaks to the east, at an altitude of 2850 feet. When the claim was visited in 1943, the only opening was a bulldozer cut about 40 feet long, in serpentinized saxonite. What little ore remained in sight consisted of medium-grained nearly massive chromite. It is said that between 20 to 30 long tons of ore has been produced from this property.

### Crescent Claim (62)

The Crescent claim, held by the Inman brothers, lies 1500 feet southeast of Inman No. 2 and is likewise on the top of the mountain. Some ore was mined from a bulldozer cut about 50 feet long, but production probably did not exceed 10 long tons. No ore was seen in place.

### Big Five Mine (63)

The Big Five mine is in the NE¼ sec. 27, T. 15 N., R. 2 E., on the steep, rocky east slope of Rattlesnake Mountain, nearly a thousand feet below the summit. It consists of the Big Five claim, held by the three Inman brothers as locators. The property was leased to Sherman Smith in 1942, but in 1943 it reverted to the owners, who have mined it ever since, and who had shipped 700 long tons of ore from it up to December 1944. Most of the ore was mined from an open bulldozer cut trending east-northeast, 85 feet long, 70 feet wide, and 60 feet deep at the face, but a small amount of mining and exploration was done through about 35 feet of tunnel and a short inclined winze.

The main ore body consisted of a lens of massive chromite about 65 feet long and 4½ to 7 feet thick, striking N. 70° E. and dipping steeply southeast. There was also some ore in the fault zones followed underground. The principal country rock is sheared, serpentinized saxonite, but some dunite is identifiable next to the ore. The ore is massive, medium-grained chromite containing little interstitial gangue and a very little uvarovite and kammererite. The chromite and serpentine are separated by a layer of gouge, and the contacts between them are sheared. Several faults, some containing as much as a foot of gouge, can be seen in the underground workings. They contain a little ore. One of them offsets a small stringer of ore, and a fault striking N. 15° E. and dipping 60° NW. completely cuts off the main ore body. The ore shipped to the Metals Reserve stockpile in Grants Pass during 1943 carried 44.03 to 49.62 percent $Cr_2O_3$ and 11.39 to 13.53 percent Fe, and had a Cr/Fe ratio of 2.41 to 2.96.

### Old Doe Mine (64)

The Old Doe mine, owned by the Inman brothers, is in sec. 22, T. 15 N., R. 2 E., on the steep east slope of Rattlesnake Mountain, several hundred feet below the top. The ore body consists of a lens of chromite about 60 feet long and 4 to 6 feet thick, trending about N. 70° E. and dipping 30° NW. This lens is surrounded by sheared serpentine, in which many unsheared boulders of saxonite and some of dunite are recognizable.

The ore has been mined with a bulldozer, which has excavated an open cut 80 feet long, 50 feet wide, and 90 feet deep in the face. The face of the cut has become so dangerously steep that continued open-cut operations would be difficult. The chromite body is offset a few feet by a fault dipping 35° N. Most of the ore is massive, medium-grained chromite. In some places disseminated ore gradational between chromite and dunite is found along the chromite-dunite contact, but in other places massive slickensided chromite is directly in contact with dunite and sheared serpentine. Uvarovite and kammererite are present in small quantity.

Up to December 31, 1944 nearly 1000 long tons of ore, containing 37.40 percent to 47.08 percent $Cr_2O_3$ and having a Cr/Fe ratio of 2.22 to 3.23, had been mined and delivered to the Metals Reserve Company's stockpile at Grants Pass.

### Big Buck Claim (65)

The Big Buck claim, owned by the Inman brothers, lies about 300 feet north and above the Old Doe mine. The ore body, little of which remains in sight, consisted of a small eastward-trending, northward-dipping lens of nearly pure chromite. The dominant country rock is sheared saxonite, but a little dunite can be identified in the open bulldozer cut.

### Midnight (66) and Goose Creek (67) Claims

C. H. McClendon has located two claims, the Midnight (altitude 1450 feet), and the Goose Creek (altitude 1300 feet), on the east slope of Rattlesnake Mountain, about 700 feet above the South Fork of Smith River. They lie within 1000 feet of the peridotite contact. No production from these prospects has been recorded and they have not been visited.

### Claim Southeast of Mud Spring (68)

The peridotite from Pigeon Roost Spring south to Mud Spring has not been thoroughly prospected. Half a mile southeast of Mud Spring is a claim located by C. H. McClendon, but no occurrence of chromite elsewhere in this vicinity has been reported. Prospecting in the steep canyon that trenches the eastern part of the peridotite in this area might uncover other chromite deposits.

## Red Mountain Area

### General Features

The Red Mountain area is near the southeast end of the southwestern peridotite belt. It is on a high ridge just north of the southern boundary of Del Norte County (see pl. 1), in the east half of R. 2 E. and the west half of R. 3 E., T. 13 N. In less than 3 miles from its southeast end, this ridge rises from an altitude of only a few hundred feet to an altitude of 4265 feet at Red Mountain Lookout, and much of the ridge is over 4000 feet above sea level.

The area was formerly reached by way of 6 miles of steep trail from Turwar, a hamlet situated on the Klamath River and 3 miles distant from the town of Klamath, which is on U. S. Highway 101. Arcata, the nearest railroad shipping point, is on this highway, about 40 miles south of the top of Red Mountain. As the trail from Turwar is now in poor condition, the area is usually entered by way of the trail running south from the road on Little Rattlesnake Mountain, 11 miles to the north. Before any large tonnage of ore can be moved from this area it will be necessary to build at least 10 miles of road.

Near Red Mountain Lookout, the peridotite outcrop widens and changes its trend from a few degrees east of south to southeast, in which direction it continues for another 4 miles. In most of the area it is about 1½ miles wide, but in places it attains a width of 2 miles. Its eastern contact dips northeastward parallel to the bedding of the Galice formation, which flanks it on that side. Its western and southern contacts have not been studied. Like the peridotite in Little Rattlesnake Mountain, it apparently occupies an anticline.

Because of its remoteness, the Red Mountain area has been but little prospected or studied. The record of activity in this area during the first World War is fragmental, but from what is known, the area appears to have promise. A great deal of chromite float lies scattered over the top of the mountain, and prospecting should uncover chromite bodies. Good outcrops of chromite are said to have been found on South Red Mountain, but none of them have been staked or opened up.

### Red Mountain Chrome No. 1 (71), No. 2 (70), and No. 3 (69) Claims

Red Mountain chrome claims Nos. 1, 2, and 3 are in sec. 18, T. 13 N., R. 3 E., at the east end of Red Mountain Meadow, 1½ miles southeast of Red Mountain Lookout, at an altitude of about 4000 feet. They are held by Kenneth Deleray of Crescent City. They probably form part of the holdings of the Big Red Mountain Chrome Mines, which lie in sec. 13 and were leased and operated by Charles E. Brewer during the first World War. Caldwell [44] reported that in 1918 the Big Red Mountain Chrome

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[44] Caldwell, F. B., Unpublished report, U. S. Bureau of Mines, 1918.

Mines held 20 claims in secs. 13 and 24, T. 13 N., R. 2 E., and in sec. 19, T. 13 N., R. 3 E. He described the mines at that time as follows:

> "Developments consist of a lot of small pits which have been stopped as soon as ore started to pinch, which in each case, it appears to have done. Although in one case, the largest workings, a flat incline 30 feet long, was said to have produced 4 distinct kidneys, each one pinching the largest having produced 10 tons, only a 2′ x 4′ showing appeared in bottom of incline at time of visit. This working was abandoned for another giving more tonnage for pack animals."
>
> "The croppings of good ore are numerous and some are of promising size. Much float is found indicating other deposits, not as yet uncovered. The results of what work has been done would tend to indicate that ore pinches quickly, for as soon as ore started to narrow, work was stopped. Several promising croppings have not been touched, except to take off part of overburden."

Seventy-two long tons of ore was mined and packed out during the first World War. When the area was visited in August 1944, two open cuts were seen on claim No. 1, both trending N. 80° W.; the larger was 25 feet long, 10 feet wide, and 7 feet deep, and the smaller was 10 feet long, 6 feet wide, and 4 feet deep. On claim No. 2 only one pit, 10 feet long, 6 feet wide, and 5 feet deep, was found. On claim No. 3 there were two pits, one 30 feet long, 10 feet wide, and 6 feet deep and the other 15 feet long, 8 feet wide, and 6 feet deep.

The predominant country rock in the Red Mountain area is a partially serpentinized saxonite, but a little dunite was seen in contact with the ore. The ore deposits on the Red Mountain chrome claims apparently consisted of small pods and lenses of high-grade disseminated and massive chromite, enclosed in shells of dunite up to 4 feet thick. The contacts of what ore still remains in place are unsheared, and the ore within short distances grades into barren dunite. No ore was seen in place on the No. 1 claim, but it is inferred from the shape of the pit that the ore body trended about N. 80° W. Ore specimens on the dump consist of massive medium-grained chromite enclosing flakes of uvarovite. Ore from claim No. 2 was of much the same character. In the south face of the northeast pit on claim No. 3, there is a 6-inch lens of ore in place that strikes N. 50° W. and dips 50° NE. The ore from this pit is nearly massive medium-grained chromite containing about 10 percent of interstitial serpentine. Ore from the smaller pit, 50 feet farther southeast, consists of euhedral crystals of chromite up to 1 centimeter in diameter. in a matrix of leached serpentine that may make up as much as 35 percent of the ore. Four long tons of ore is stacked on the dumps of the No. 1 claim, something less than 1 ton on the No. 2 claim, and about 3½ tons on claim No. 3.

## PROPERTIES IN EASTERN PERIDOTITE BELT

### Bear Camp Ridge-Doe Flat Area

The chromite deposits that have been mined in the Bear Camp Ridge-Doe Flat area form three groups, one at Bear Camp Ridge, one at Youngs Valley, and one at Doe Flat. Most of the Doe Flat area, including the one deposit that has been mined, lies within Siskiyou County.[45]

The Bear Camp Ridge-Youngs Valley Forest Service road traverses this peridotite area lengthwise. This road leaves the graveled county road at Waldo, Oregon, and ends at Youngs Valley, 16 miles to the south.

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[45] Wells, F. G., Rynearson, G. A., and Cater, F. W., Chromite deposits of Siskiyou County, California: In preparation.

Waldo is 8 miles by the county road from Cave Junction, Oregon, on Highway 199, and Cave Junction is 26 miles southwest of Grants Pass.

Outcrops of peridotite extend almost due south from the Oregon border to Doe Flat, a distance of 12 miles. At no place is peridotite exposed for as much as 2 miles in width and in places it narrows to one-third of a mile. The peridotite appears to be a tabular body lying between the steeply eastward dipping Galice formation on the west and metavolcanic rocks of Triassic age [46] to the east. Its western contact is faulted and shows some irregularities of strike due to the inslicing of the enveloping rocks. Its eastern contact with the metavolcanic rocks is complicated by bodies of diorite and granodiorite and related rocks which intrude both the peridotite and metavolcanic rocks. The peridotite is serpentinized and highly sheared throughout much of its length.

### White Feather Claim (22)

The White Feather claim is in Del Norte County, just north of the Siskiyou County line, in the SE¼ sec. 4, T. 17 N., R. 5 E. It is on the north slope of an eastward-trending shoulder of Youngs Peak, at an altitude of 5300 feet. The deposit was discovered by Homer White in 1917, and was held in 1940 by F. A. Andrews and C. W. Van Luven. In 1942, Baker Bros. and the Jones Mining Company shipped 65 long tons of chromite from this property.

The deposit lies about 100 feet south of the northern contact of a small, irregular body of peridotite that has a total area of less than 1 square mile. Exposures are poor, but when the deposit was visited in 1940 its top had been completely uncovered. It consisted of an irregular pod of massive chromite, trending about N. 20° W., which had a maximum length of 30 feet, an average width of 8 feet, and was bottomed at a depth of 4 feet. The ore was massive and coarse-grained; it was surrounded by slickentite, and fracture surfaces in the ore were polished and striated by movement. After this pod had been mined no other ore was found. According to Allen[47], a sample assayed 37.88 percent $Cr_2O_3$, 12.6 percent FeO, and 2.03 percent $SiO_2$ and had a Cr/Fe ratio of 2.63.

### Ebon Claim (20)

The Ebon claim is in sec. 17, T. 18 N., R. 5 E., on the west slope of Bear Camp Ridge and 100 feet below the crest; it was only a few hundred feet above the lower peridotite contact. The property has not been examined by a Geological Survey geologist, but the owner, J. W. Eggers, reported that he shipped 5 long tons of 48-percent chromite ore from the property in 1943.

## Dunn Creek Area

### Alyce and Blue Jay Claims (21, 21a)

The Alyce and Blue Jay claims were located during the first World War by J. W. Eggers and G. G. Shaddinger, who leased them to W. E. Gilmore. Gilmore is reported to have shipped about 40 long tons of ore, containing about 49 percent chromic oxide, from the Alyce claim. No ore was shipped from the Blue Jay claim, and neither claim has been worked during the present war. The following description is largely paraphrased from a report by Caldwell made in 1918.

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[46] Wells, F. G., and Hotz, P. E., Mesozoic volcanic series in southwest Oregon: (abstract) Geol. Soc. America Bull., vol. 52, p. 1937, 1941.

[47] Allen, J. E., op. cit. p. 124.

The Alyce claim is in sec. 23, T. 18 N., R. 5 E., near the crest of Middle Ridge and about 2 miles north of Black Butte. To reach the property, one follows a dirt road for about 4 miles south from Takilma, Oregon, and then follows a trail for 2½ miles. More than 12 tons of chromite float was scattered over this claim; the largest piece was 4 by 5 by 6 feet and contained 9 or 10 long tons of dense chromite. At the time of visit, the claim had been explored by one cut 15 feet long and several small trenches. The main cut exposed a shear zone of slickentite, which trends N. 65° W. and dips 45° SW. In this zone a body of fine-grained homogenous chromite 1 foot wide and 4 feet high lay loose on a hard, compact, serpentine footwall and was surrounded by slickentite. On the surface, sandy chromite float extended for 200 to 300 feet southeast of this cut, in the direction of the strike.

The Blue Jay claim lies about half a mile north of the Alyce. As this claim has had no production, it is not described.

## BEACH SAND DEPOSITS

### General Statement

For 17½ miles south of the Oregon boundary the coast of Del Norte County is bordered by an emerged marine terrace. The rock floor of this terrace crops out at Point St. George and in a few scattered stacks that project through the recent or late Pleistocene unconsolidated beach deposits, but in some places, as has been proved by drilling, it is as much as 60 feet below sea level.[48] Elsewhere along the Pacific Coast, terraces of Pleistocene age are distinctive features of the mountain front. Near Coos Bay and Humboldt Bay there are terraces at levels of 80 to 100 feet, 170 to 220 feet, 275 to 375 feet, and 500 to 600 feet.[49] They are mantled with beach and offshore deposits, and some of them contain significant concentrations of heavy minerals. In the Crescent City area, terraces at the corresponding levels are poorly developed, if developed at all.

Remnants of sand, silt, and gravel containing late Tertiary fossils are found on the ridges north and south of Smith River, and also at the mouth of the South Fork, 18 miles inland from the coast. At the time these sediments were deposited all the area now below an altitude of 2100 feet apparently formed part of a great embayment covering several hundred square miles. The present marine terrace occupies but a small fraction of this area. The deposits on it consist of detritus that was first brought to the sea in late Tertiary time but repeatedly worked over as one terrace after another was cut by marine planation. This process has stripped most grains of heavy minerals of all adhering rock material, has broken up fragments of heavy rock that might contaminate concentrations of heavy minerals, and has classified the detritus to a limited range of grain size. It is only in such clean, graded sand that large minable concentrations containing hundreds of thousands of tons of heavy sand are likely to be found.[50]

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[48] Mr. Daniel C. Beyer reports that he drilled along the old railroad grade east of Fort Dick. A hole 85 feet deep, located where the road meets the grade, did not reach bedrock, but the lowest part of it passed through 30 feet of black muck. Another, about half a mile farther north, was 60 feet deep and penetrated slate bedrock. A third, on the bank of Smith River, was 65 feet deep and failed to reach bedrock.

[49] Griggs, A. B., Chromite-bearing sands of the southern part of the coast of Oregon: U. S. Geol. Survey, Bull. 945-E, pp. 117-118, 1945.

[50] Wells, F. G., The origin of economically significant sedimentary deposits of heavy minerals: In preparation.

Near Crescent City the marine terrace is generally flat, but it is locally diversified by sand dunes and sloughs, and several lakes have been formed on it by the growth of offshore bars. As most of it was once a beach, deposits of heavy minerals may be found in any part of it where conditions are favorable. As the prevailing winds are from the south, sand deposits are frequently formed on the south sides of headlands and at the foot of the seacliff, and they may also form a few hundred feet offshore. Deposits of considerable size may therefore lie along the seacliff in the vicinity of the village of Smith River, unless the configuration of the rock floor is there unsuitable or unless the deposits have been destroyed by Smith River on its wandering course to the sea. Systematic drilling and sampling will be necessary before it will be possible to obtain adequate knowledge of the size, grade, and distribution of any heavy-sand concentrations that may be present.

### Crescent City Beach Deposits

The only large concentration of heavy sand now known to occur in Del Norte County lies along the arcuate beach south of Crescent City. It extends from the breakwater at Whaler Island, 4.5 miles south. On both the foreshore and backshore, which is now inactive, black sand has been mined intermittently for gold and platinum. A plant for recovering those metals was erected in 1913[51], but the operation was not successful. In 1934 the Pacific Bridge Company explored this and other areas on the marine terrace by drilling and by sinking caissons. They were then interested only in gold and platinum, but in 1942, while testing the area as a possible source of iron, they found that the sand contained an appreciable amount of chromite.

Along this beach the foreshore is relatively narrow, except within the jetties of Crescent City Harbor, where it is about 500 feet wide. The remainder is estimated to be about 200 feet wide at low tide and 50 feet wide at high tide. The foreshore deposits are in general about half sand and half gravel, but gravel is more abundant at the southern end. The back part of the foreshore, just in front of the seacliff, is covered with driftwood. The seacliff is well marked at the southern end of the terrace, but northward it gradually becomes less so, and within half a mile it disappears, giving way to a ridge of sand, gravel, and driftwood about 10 feet high. A mile or so farther north this ridge is in turn replaced by a bank 2 to 5 feet high. The backshore begins at the end of the cliff and widens northward, grading into a coastal plain which continues to Smith River, 12 miles to the north. To a depth of 4 feet—the greatest depth at which samples were taken—the backshore deposit was mostly sand, but tailings piles from former mining in the backshore contained a considerable amount of gravel. Mr. R. H. Coles, a local miner, said that the average depth of the deposit was 5 feet on the foreshore and 11 feet on the backshore. These figures may be a bit high, but they are probably not much in error, at least for the central part of the beach.

The proportion of black sand concentrated in the foreshore and backshore deposits varies considerably. The better concentrates are in a strip that extends about 2 miles south from a point about half a mile southeast of the end of the south jetty. Here the percentage of black sand probably ranges from about 10 to about 50 percent and averages between 15 and 25 percent. The best concentrations were in the back 50 to 75 feet of the foreshore, but, as the backshore contained less gravel, the overall average is probably about the same. Good concentrations were seen as far as 500 feet landward from the seacliff in the backshore, and they probably continue even farther.

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[51] Maxson, J. H., op. cit., p. 143.

The percentage of ilmenite and magnetite in the black sand is reported to be high, but Howard Malaney of the Pacific Bridge Company said that the samples he collected carried 4 to 11 percent $Cr_2O_3$ and averaged 7 percent. He took 56 samples in a strip extending 2800 yards south from a small stream southeast of Crescent City (72, pl. 1). He laid out lines normal to the coast lines and 100 yards apart, and on each line he took one sample from the foreshore and one from the backshore, at an average distance of 200 feet apart and to an average depth of 3 feet. From the results of this sampling, he estimated that a strip 2 miles long, 250 to 370 feet wide (this includes 50 to 75 feet of foreshore and 200 to 300 feet of backshore), and 3 to 5 feet deep contained at least 500,000 cubic yards of heavy sand.

Several samples of sand from this area were tested in 1918. One sample, having a dry weight of 2418 pounds, submitted by the California Chrome Company to Dr. Milnor Roberts of the University of Washington, assayed 26.2 percent $Cr_2O_3$ and 25.8 percent total FeO. This sample must have been from an exceptionally rich layer. The sand gave the following screen test:

*Screen test on sand from Crescent City deposits*

| All passes | 20 mesh | Weight | Percent | Cumulative percent |
|---|---|---|---|---|
| Retained on | 28 | 0.60 g. | 0.12 | 0.12 |
| | 35 | 2.00 | 0.40 | 0.52 |
| | 48 | 20.10 | 4.02 | 4.54 |
| | 65 | 144.30 | 28.86 | 33.40 |
| | 100 | 281.70 | 56.34 | 89.74 |
| | 150 | 44.20 | 8.84 | 98.58 |
| | 200 | 1.60 | 0.32 | 98.90 |
| Passing | 200 | 2.00 | 0.40 | 99.30 |
| | | | 99.30 | |

Dr. Roberts reports that the chief minerals found under the lens in the screened material were white and yellow quartz in rounded grains, red and pink garnet, black chromite, and magnetite. Black minerals were most abundant in the + 65 mesh, + 100 mesh, and + 150 mesh fractions.

A sample of material from which most of the chromite and magnetite had been removed was submitted to G. E. Stowell for microscopic examination. He reported that the minerals present in appreciable quantity were, in order of abundance, zircon, magnetite, quartz, ilmenite, chromite, garnet, and monazite; there were also a few grains of olivine, chrome spinel, rutile, and corundum, and a few specks of gold and platinum.

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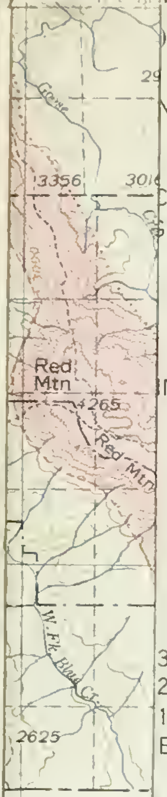
PARTMENT



NTAIN

C CLENDON

GERS

NG

41°30'

3

2

1

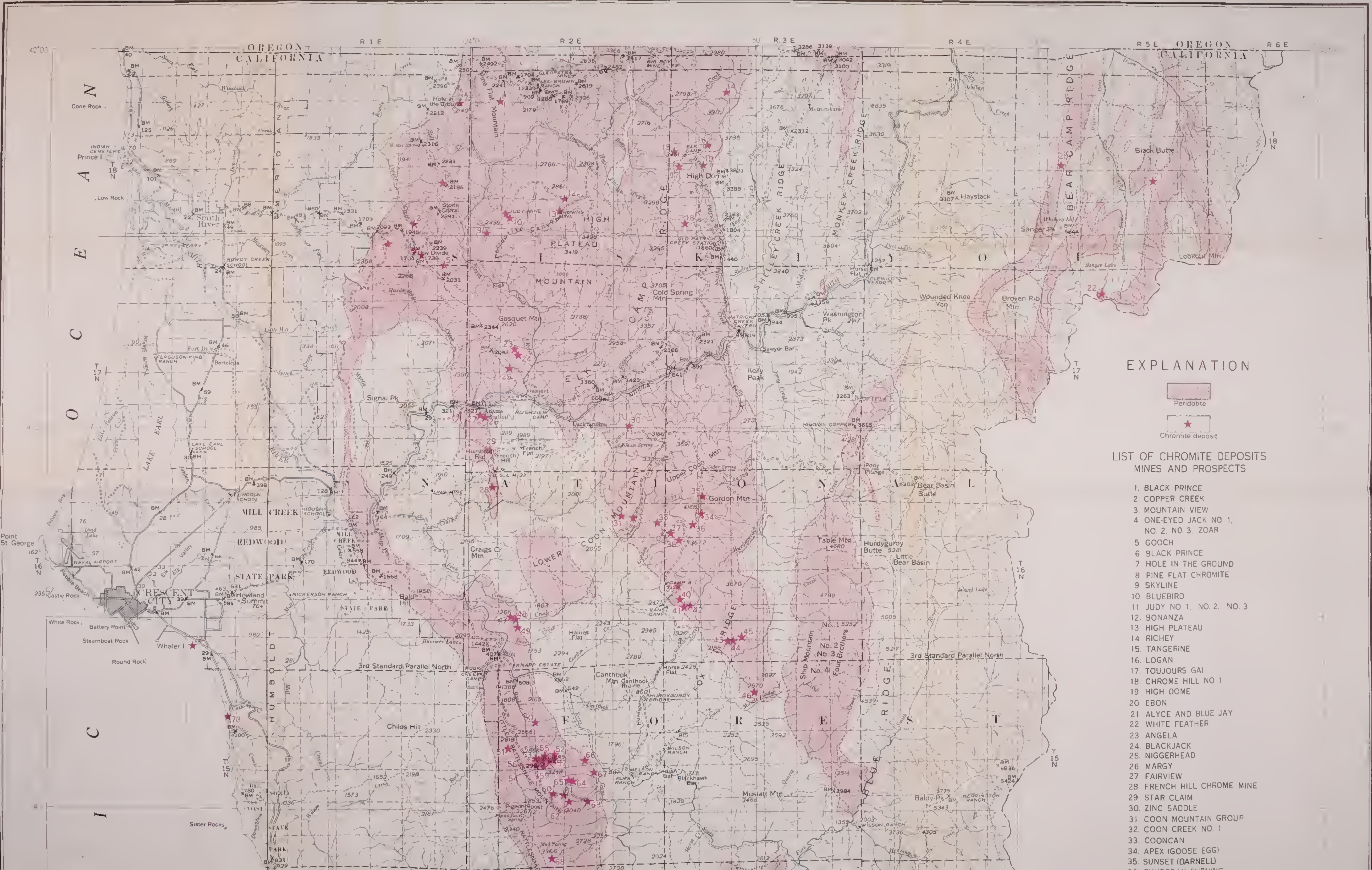
BEACH DEPOSIT

accurately located

DIVISION OF MINES
WALTER W. BRADLEY STATE MINERALOGIST
OLAF P. JENKINS CHIEF GEOLOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CALIFORNIA DIVISION OF MINES
BULLETIN 134 PART I, PLATE 1



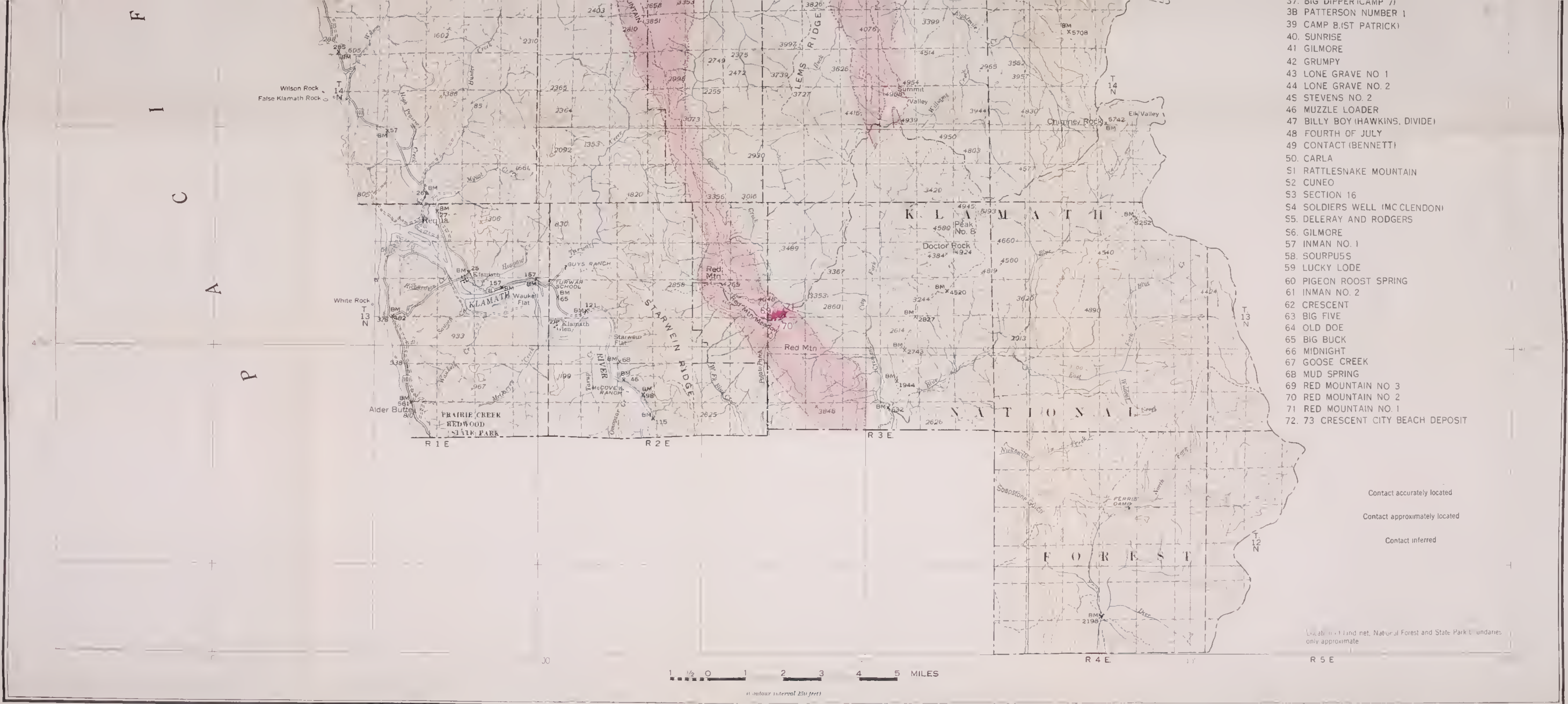
EXPLANATION

▨ Peridotite

★ Chromite deposit

LIST OF CHROMITE DEPOSITS
MINES AND PROSPECTS

1. BLACK PRINCE
2. COPPER CREEK
3. MOUNTAIN VIEW
4 ONE-EYED JACK NO 1, NO. 2, NO. 3, ZOAR
5 GOOCH
6 BLACK PRINCE
7 HOLE IN THE GROUND
8 PINE FLAT CHROMITE
9 SKYLINE
10 BLUEBIRD
11 JUDY NO 1, NO. 2, NO. 3
12. BONANZA
13 HIGH PLATEAU
14 RICHEY
15. TANGERINE
16. LOGAN
17. TOUJOURS GAI
18. CHROME HILL NO 1
19 HIGH DOME
20 EBON
21 ALYCE AND BLUE JAY
22 WHITE FEATHER
23 ANGELA
24. BLACKJACK
25. NIGGERHEAD
26 MARGY
27 FAIRVIEW
28 FRENCH HILL CHROME MINE
29 STAR CLAIM
30. ZINC SADDLE
31 COON MOUNTAIN GROUP
32. COON CREEK NO. 1
33. COONCAN
34. APEX (GOOSE EGG)
35. SUNSET (DARNELL)



Base map compiled from topographic maps prepared by
United States Department of Agriculture Forest Service
under the direction of the Chief of Engineers, U S Army,
1943 and from topographic maps prepared by
United States Department of the Interior, Geological Survey

Lith. A Hoen & Co Inc

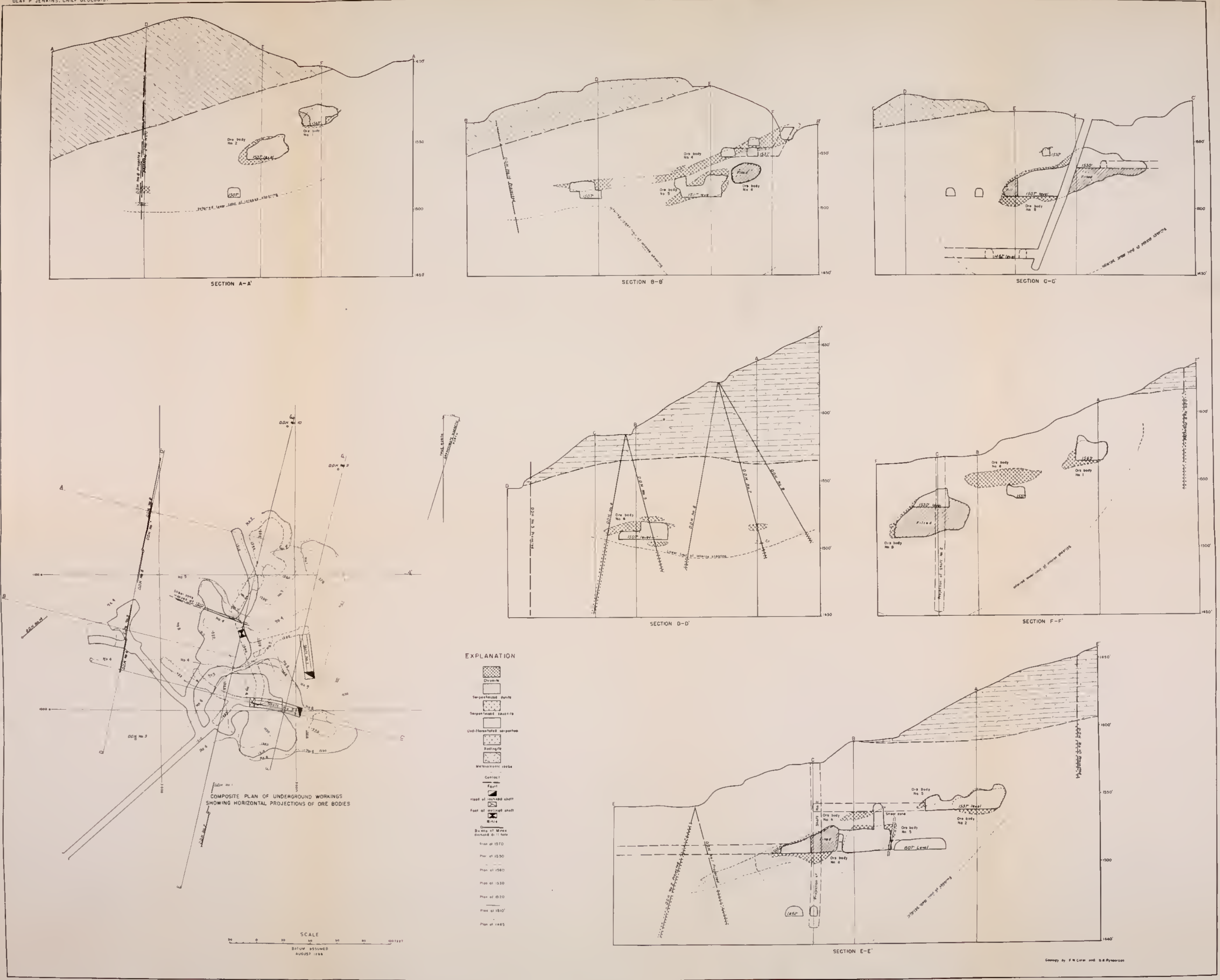
# TOPOGRAPHIC MAP OF DEL NORTE COUNTY, CALIFORNIA
# SHOWING DISTRIBUTION OF PERIDOTITE AND LOCATION OF CHROMITE DEPOSITS

BY FRANCIS G. WELLS

GEOLOGICAL SURVEY, U. S. DEPARTMENT OF THE INTERIOR

1946

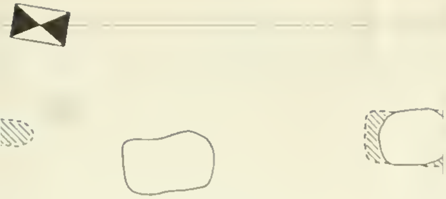
Geologic mapping west of meridian 123 45 by Fred W. Cater
and Francis G. Wells. Geologic mapping east of meridian 123 45
by John H. Maxson, modified by Francis G. Wells



Geology by F. W. Cater and G. B. Rynearson

PLAN OF UNDERGROUND WORKINGS AND SECTIONS OF WEST ORE ZONE, FRENCH HILL MINE, DEL NORTE COUNTY, CALIFORNIA

PLAN AT 2440

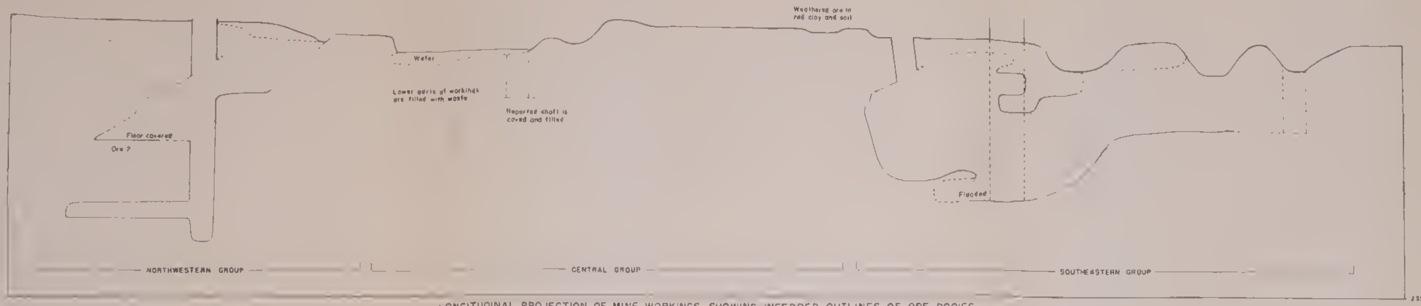


PLAN AT 2440

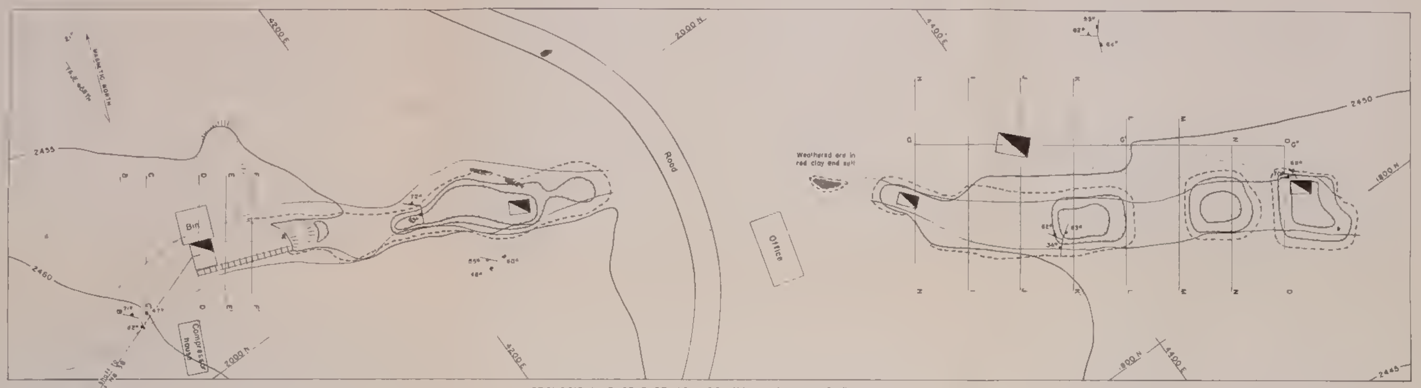
DIVISION OF MINES
W BURLING TUCKER, STATE MINERALOGIST
OLAF P JENKINS, CHIEF GEOLOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

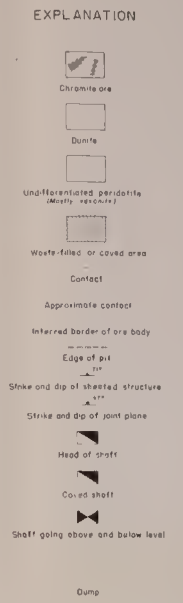
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

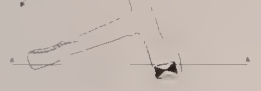

Weathered ore in red clay and soil
Water
Lower parts of workings are filled with waste
Reported shaft is caved and filled
Floor covered
Ore ?
Flooded
NORTHWESTERN GROUP
CENTRAL GROUP
SOUTHEASTERN GROUP
2350

LONGITUDINAL PROJECTION OF MINE WORKINGS, SHOWING INFERRED OUTLINES OF ORE BODIES

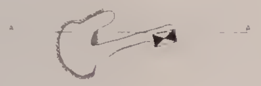


GEOLOGIC MAP OF SURFACE WORKINGS AND ADJACENT AREA

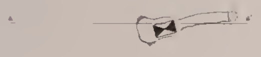

EXPLANATION
Chromite ore
Dunite
Undifferentiated peridotite (Mostly saxonite)
Waste-filled or caved area
Contact
Approximate contact
Inferred border of ore body
Edge of pit
Strike and dip of sheeted structure
Strike and dip of joint plane
Head of shaft
Caved shaft
Shaft going above and below level
Dump



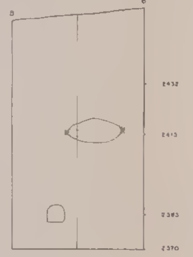
PLAN AT 2383



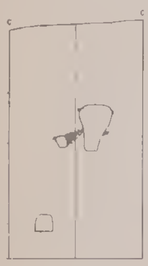
PLAN AT 2413



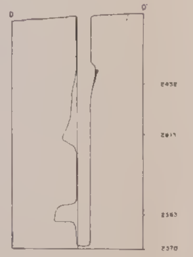
PLAN AT 2432



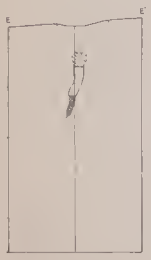
SECTION B-B'



SECTION C-C'



SECTION D-D'



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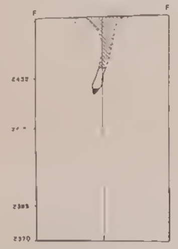
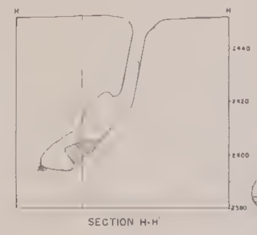
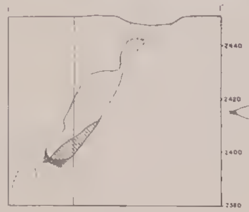


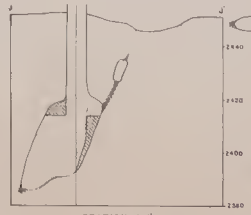
SECTION F-F'



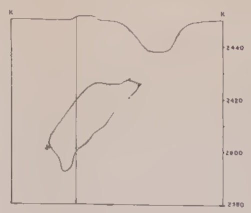
SECTION H-H'



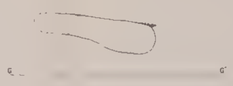
SECTION I-I'



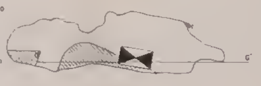
SECTION J-J'



SECTION K-K'



PLAN AT 2390



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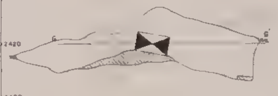

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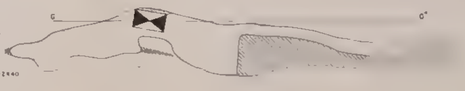

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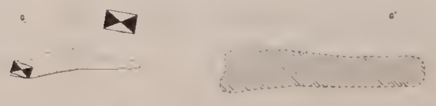

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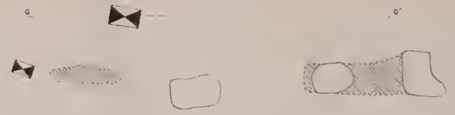

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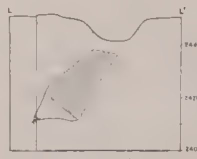
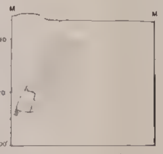


SECTION L-L'



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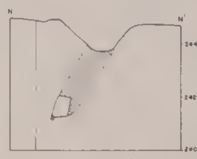
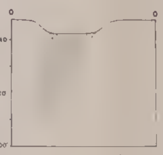


SECTION N-N'

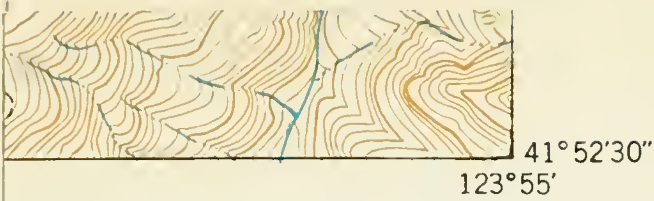


SECTION O-O'

# GEOLOGIC MAP AND SECTIONS
# OF THE
# MOUNTAIN VIEW MINE
## DEL NORTE COUNTY
## CALIFORNIA

GEOLOGY AND SURVEYING BY G A RYNEARSON,
F W CATER, JR., O H DOW, AND W P WILLIAMS
SURVEYED DURING PARTS OF JUNE AND
AUGUST 1943

CONTOUR INTERVAL 5 FEET
DATUM ASSUMED



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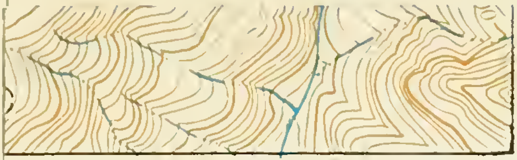

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DEPARTMENT OF NATURAL RESOURCES

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UNITED STATES DEPARTMENT OF THE INTERIOR
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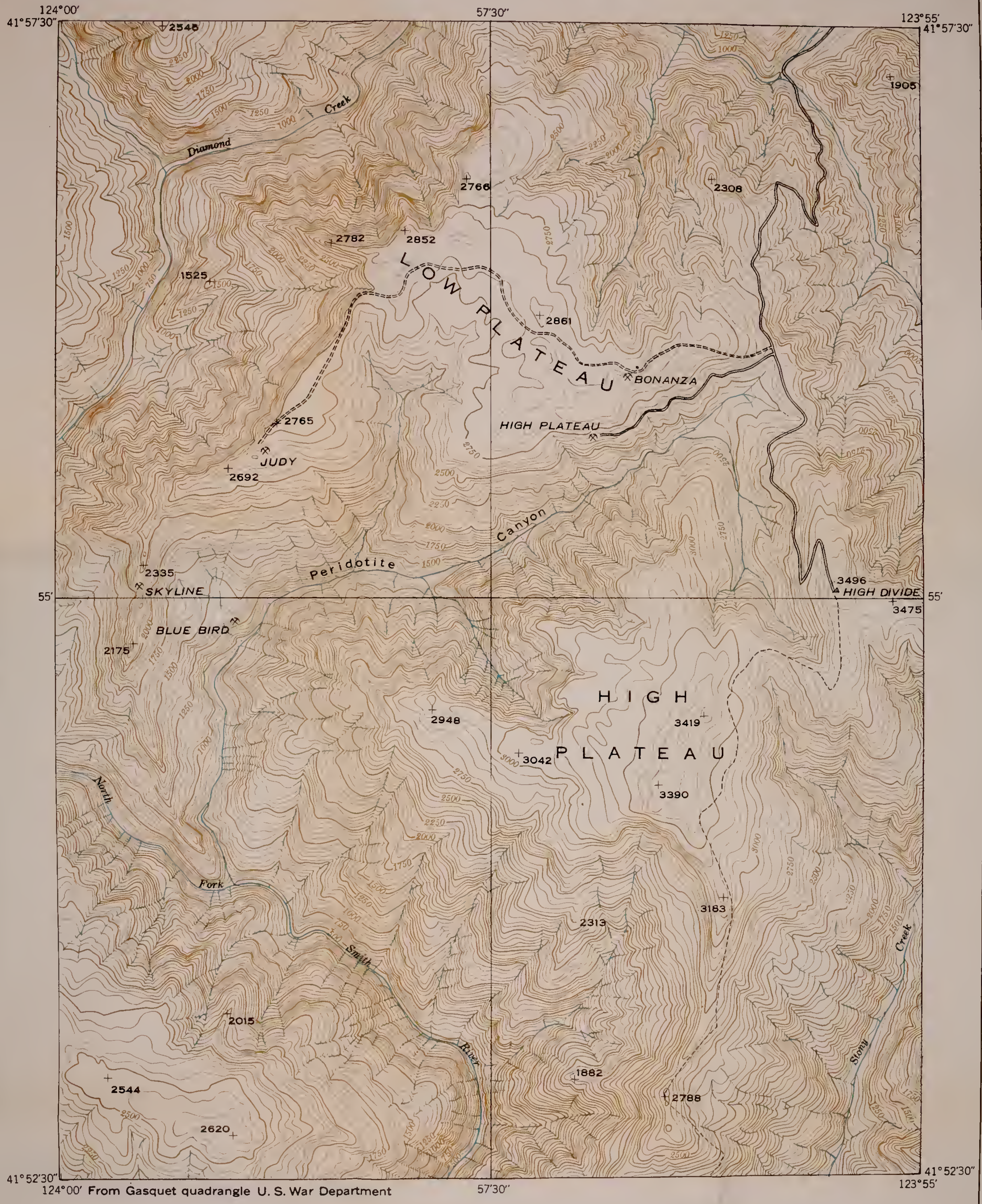

From Gasquet quadrangle U. S. War Department

# MAP OF HIGH PLATEAU AND VICINITY
## SW. ¼ OF T. 18 N., R. 2 E.

0 1 2 MILES
0 5,000 10,000 FEET

*Contour interval 50 feet*

DIVISION OF MINES
W. BURLING TUCKER, STATE MINERALOGIST
OLAF P. JENKINS, CHIEF GEOLOGIST

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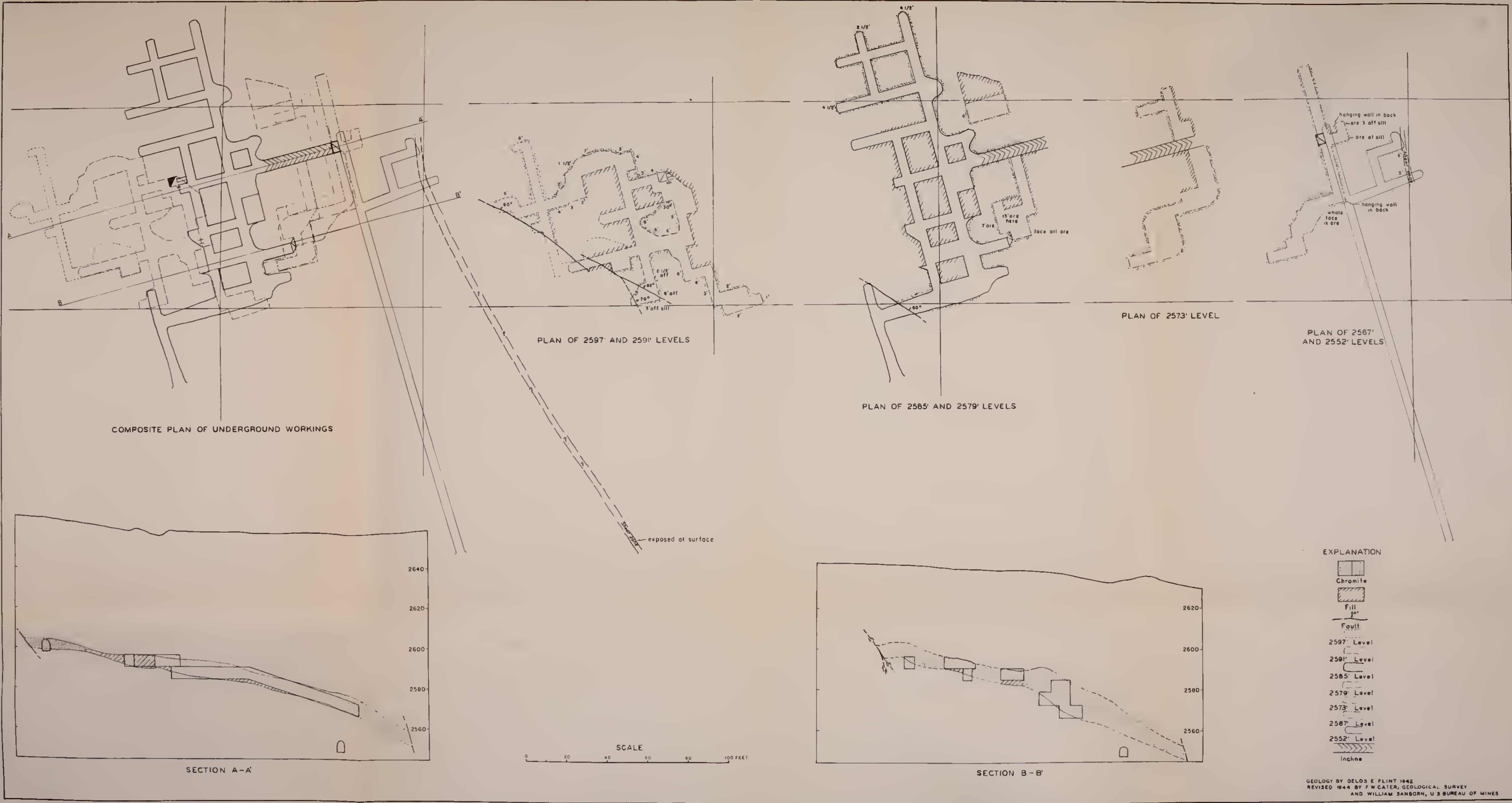
BULLETIN 134, PART I, PLATE 6



GEOLOGY BY DELOS E. FLINT 1942
REVISED 1944 BY F. W. CATER, GEOLOGICAL SURVEY
AND WILLIAM SANBORN, U. S. BUREAU OF MINES

PLANS AND SECTIONS OF THE HIGH PLATEAU MINE, DEL NORTE COUNTY, CALIFORNIA

DIVISION OF MINES
W. BURLING TUCKER, STATE MINERALOGIST
OLAF P. JENKINS, CHIEF GEOLOGIST

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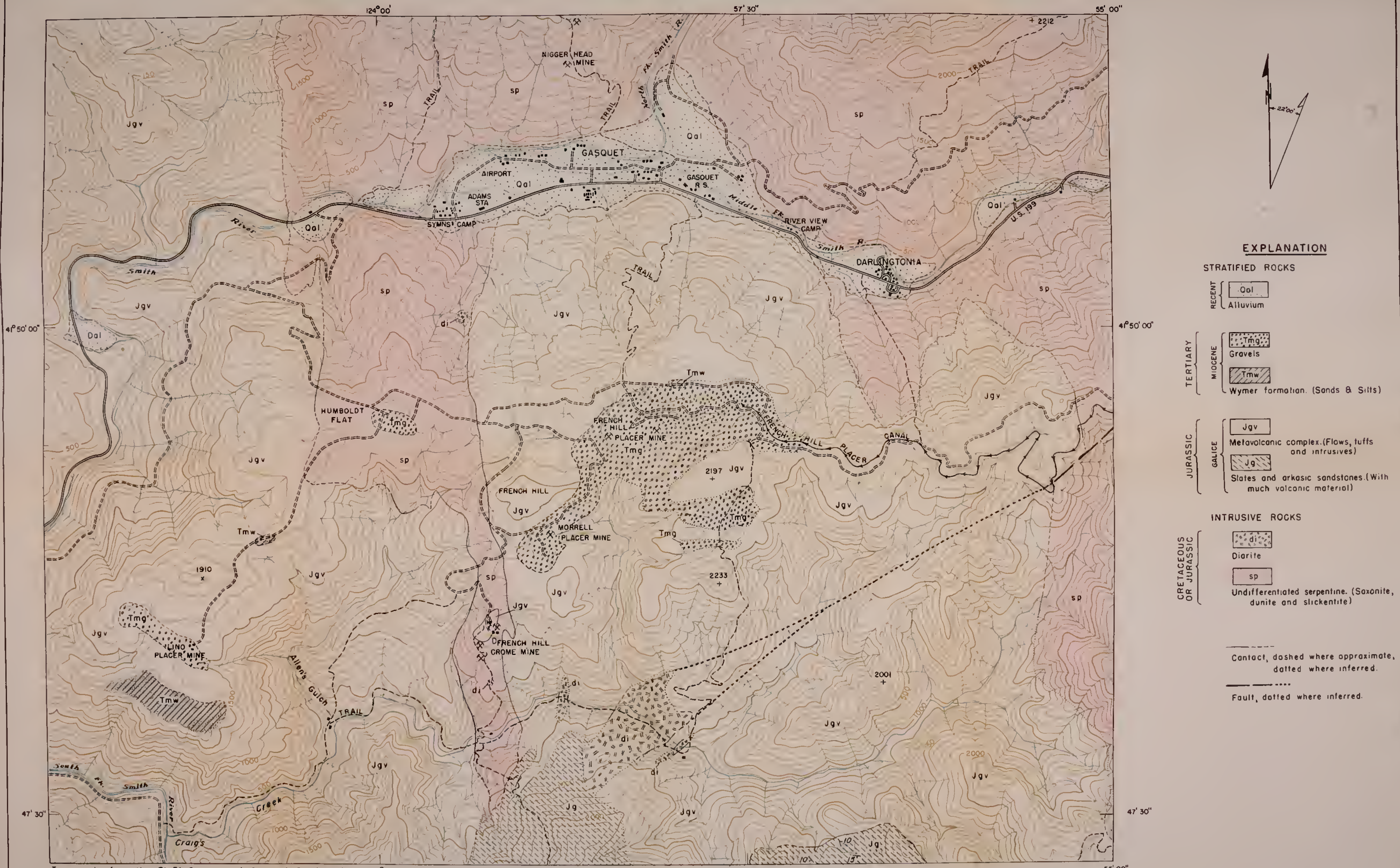
BULLETIN 134, PART I, PLATE 8



Topography from the Pt St George and Gasquet Quadrangle sheets issued by the War Department, U.S. Engineers

Geology by Fred W Cater Jr

# GEOLOGIC MAP OF THE FRENCH HILL AREA
## DEL NORTE COUNTY, CALIFORNIA

Datum is mean sea level

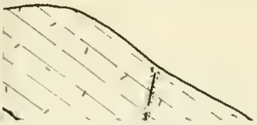
Contour interval 100 feet

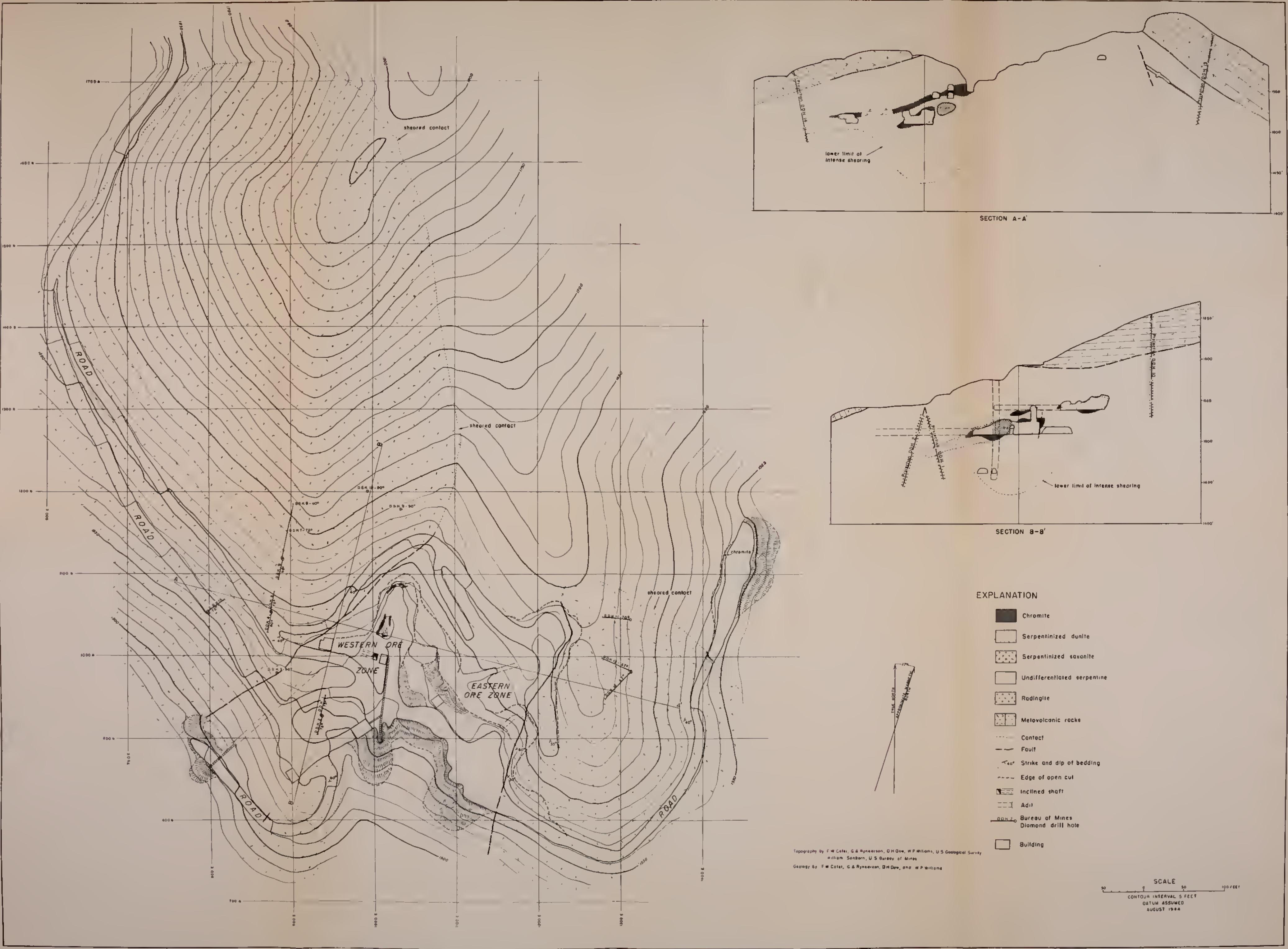
SCALE $\frac{1}{24000}$

1000 0 2000 4000 6000 FEET

F CALIFORNIA
NATURAL RESOURCES

BULLETIN 134, PART I, PLATE 9





SECTION A-A'

SECTION B-B'

Topography by F W Cater, G A Rynearson, D H Dow, W P Williams, U S Geological Survey
William Sanborn, U S Bureau of Mines
Geology by F W Cater, G A Rynearson, D H Dow, and W P Williams

GEOLOGIC MAP AND SECTIONS OF THE FRENCH HILL MINE, DEL NORTE COUNTY, CALIFORNIA

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